DECEMBER 7, 1978

VLSI, SENSORS LEAD TOPICS AT ELECTRON DEVICES MEETING/128

Designing microprocessor-controlled alphanumeric displays/137

How standard symbols simplify logic design/143

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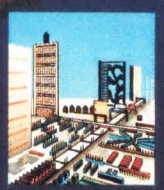

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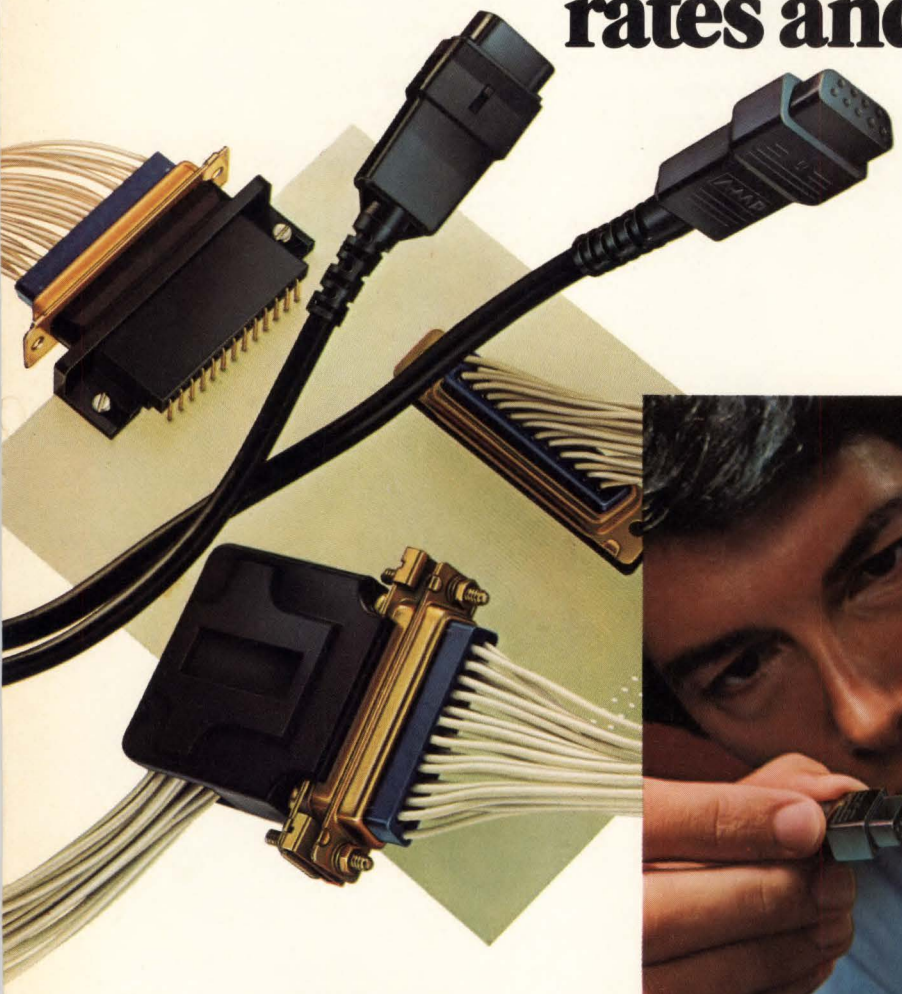

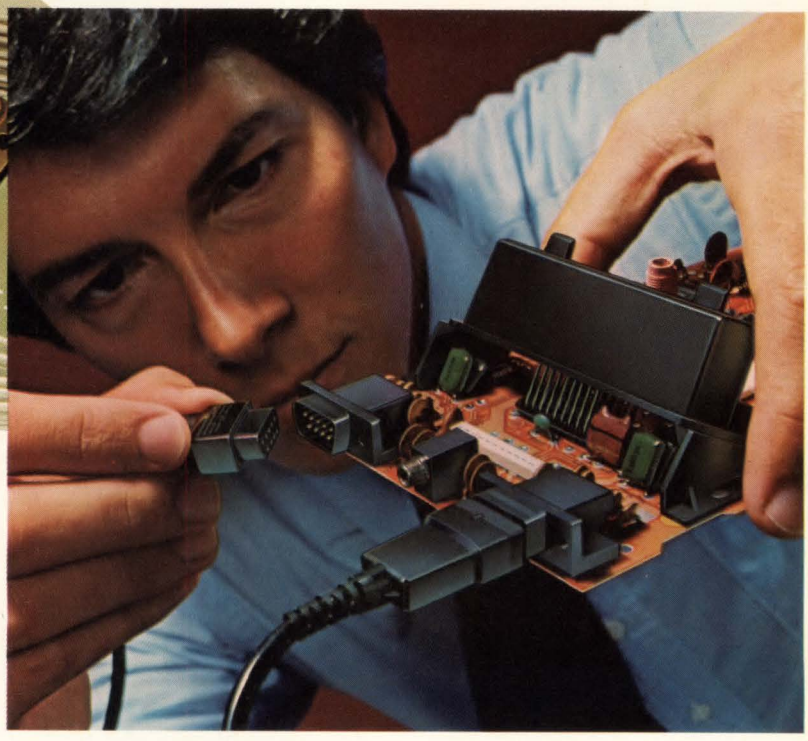

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Highlights

Cover: Distributed processing advances, 107
Price and performance improvements in computer and data-communications hardware, plus simpler, more powerful software, are making distributed data processing a reality. This special report examines the state of the distributed processing art and how it may shape the future for both computers and communications.

John Ashworth photographed the cover.

AT&T gives more answers about ACS, 83
In response to questions from the Federal Communications Commission, AT&T has provided details on its proposed Advanced Communications Service. Computer and communications firms, however, are calling for more.

IEDM spotlights 1-μm lines, GaAs, 129
Invited papers discuss the best routes to fine-line geometries for very large-scale integration, gallium arsenide's advantages over silicon, and the present state and possible future of sensors.

Alphanumeric display gets smart, 137
Adding a microprocessor to control a system's alphanumeric display leaves the central processing unit free for computation.

And in the next issue . . .
Electronics executives' outlook on 1979 . . . Part 3 of the special report on fiber-optic data links . . . designing low-power switching supplies.

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Publisher's letter

In the last 12 months, the number of architectures for distributed-computer networks has doubled, a remarkable trend signifying the rapid rise in importance of distributed processing. This popularity has affected mainframes, minicomputers, and terminal equipment to the point where it is difficult to get even halfway consistent estimates of what the entire distributed processing market will be.

For his special report on this subject (p. 107), computers editor Tony Durniak has prepared a chart that lists all the new architectures and their basic parameters. Tony fully expects several more to be announced in the next 12 months, though the number will probably not double again as it has in the previous year. "As these products improve, the complexion of the computer industry and the technology will alter," Tony predicts.

Using the annual National Computer Conferences as milestones shows how swift has been the arrival of the idea, he adds. In June 1976, the subject was first discussed. By June 1977, "distributed processing" was a buzz word, but there was not much in the way of products. But by June 1978, there was equipment truly capable of distributed processing.

While Tony's special report concentrates on the new network architectures, there are ramifications for ancillary equipment. The influence of distributed processing technology and software will probably begin to encourage the use of computers in office word processing, electronic funds transfer systems, and point-of-sale systems.

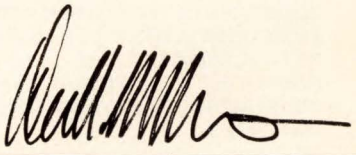
"I have never seen so many companies jump on a bandwagon so fast. Distributed processing concepts have lured in many companies, creating more activity in less time than any other data-processing innovation," Tony observes.

In this issue we are beginning our annual series of market reports from Western Europe. The first, on page 87, is from the United Kingdom and was prepared by London bureau manager Kevin Smith.

Kevin reports that, with the labor unions pushing for double-digit pay increases, the specter of inflation followed by countermeasures that would also slow the economy has the British worried.

Electronic-equipment markets are expected to grow by 10.7%, however, following a 13.6% gain this year. Kevin predicts similar growth for the British components makers—up some 7.8% in 1979, a marked slowdown from 1978's 10.5% growth rate.

Other reports from Europe will cover West Germany, France, Italy, and Scandinavia. These individual outlooks will be in addition to the European market report included with the *Electronics* world markets report published in the Jan. 4, 1979 issue. As usual, that report will include information on the United States, Europe, and Japan.



December 7, 1978 Volume 51, Number 25 97,481 copies of this issue printed

Published every other Thursday by McGraw-Hill, Inc. Founder: James H. McGraw 1860-1948. Publication office 1221 Avenue of the Americas, N.Y., N.Y. 10020; second class postage paid at New York, N.Y. and additional mailing offices. ID# 172400.

Executive, editorial, circulation and advertising addresses: Electronics, McGraw-Hill Building, 1221 Avenue of the Americas, New York, N.Y. 10020. Telephone (212) 997-1221. Teletype 12-7960 TWX 710-581-4879. Cable address: M C G R A W H I L L N E W Y O R K.

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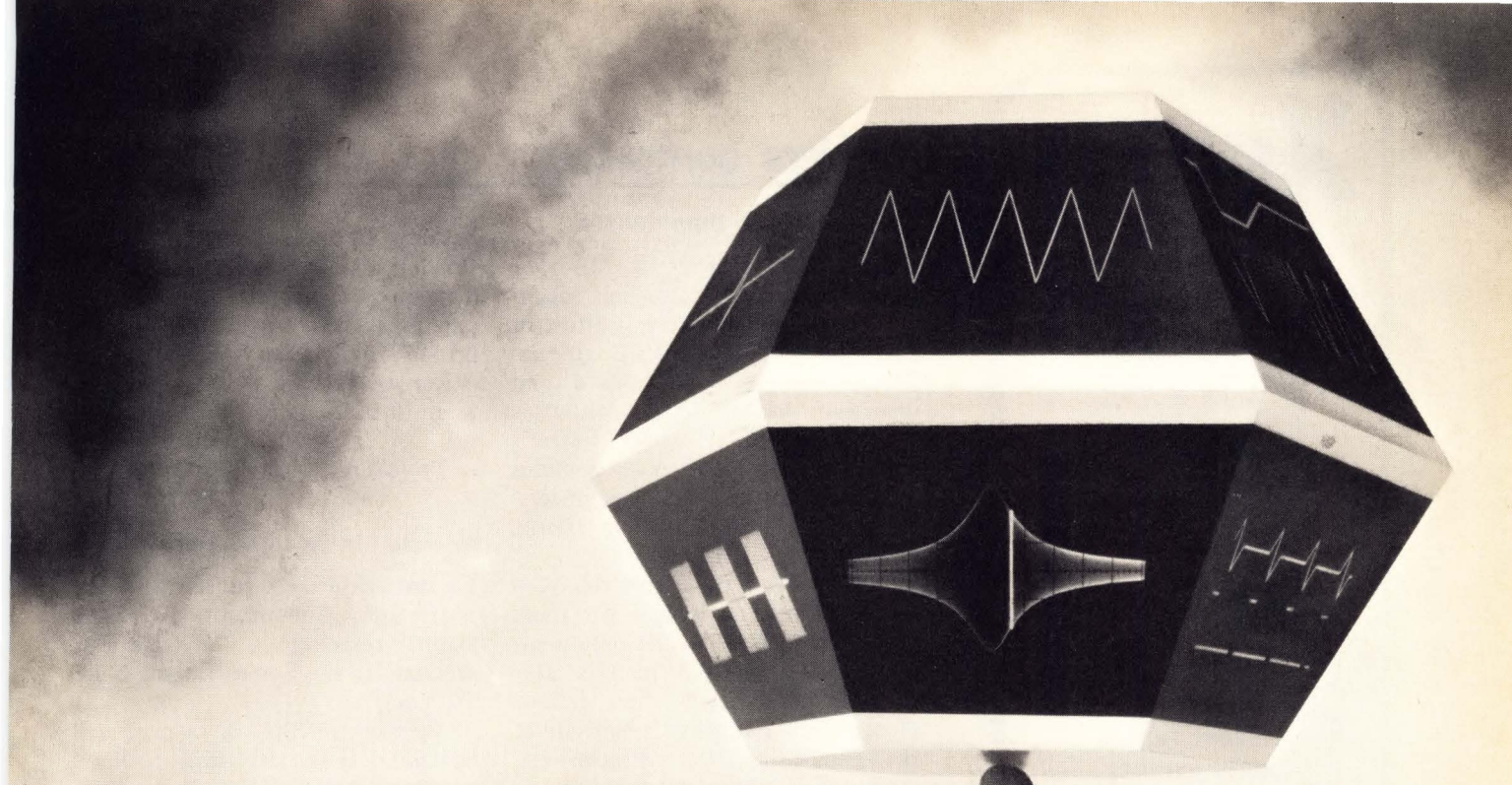

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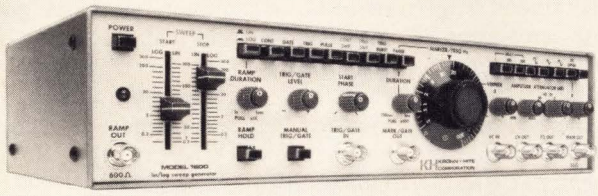

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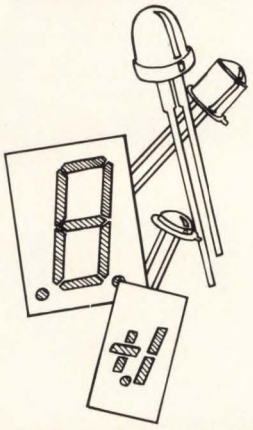

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Readers' comments

'Actions louder than dollars'

To the Editor: In your Oct. 12 issue [p. 6], Bruno O. Weinschel, executive vice president of the Institute of Electrical and Electronics Engineers' Professional Activities Board and chairman of its U. S. Activities Board, replied to Irwin Feerst's statement that the IEEE denudes itself of funds in areas of engineers' pensions, anti–wage busting efforts, and problems of age bias.

Weinschel's reply is that the USAB has increased its budget for these areas. His defense is not only poor, but misleading, and in this case actions speak louder than dollars. Here is how Faith Lee, chairman of the Princeton, N. J., Professional Activities Committee, reported on the September 1978 National PACUSAB meeting in Los Angeles:

"The two gut issues of wage busting and pensions reform were left off the agenda completely. Although many engineers [had] protested, Dr. Weinschel restored the topic of wage busting to the program only after a member of the board of directors intervened. Pensions never did get into the act, although the majority of engineers have no pension and never will, according to present statistics."

Note the power exercised by Weinschel to keep these issues off the agenda and maintain a low profile on them, and thus ensure their failure. Further, John Alexander, the USAB's project leader for anti–wage busting, reported on his many fruitless attempts to contact Dr. Weinschel on the subject and the withdrawal of the USAB's support of Congressman Corman's H.R. 314 and the disastrous results.

I^2R is not the only type of power with which engineers must be familiar. There is also a power struggle within the IEEE. As engineers, we all should know about this conflict. Corporate officers such as Weinschel and educational leaders have represented the practicing engineer for too long and with damaging results.

The engineers that are not members of the IEEE are in part responsible. They have failed to support those who are fighting to build a better IEEE and a better profession. It is our task to replace the businessmen and opportunists that damage our profession by controlling our professional society. This is the power struggle we all must join and we must win.

Richard F. Tax
Professional Activities Committee
N. J. Section, IEEE

No help for the uncooperative

To the Editor: I disagree with the Washington Commentary on easing export restrictions on computer products to the Soviet Union [Sept. 28, p. 62].

Although all the points may well be valid, it is the lack of cooperation by the Soviet Union in any agreement that makes this proposition undesirable. Is the Soviet government, in exchange for the lifting of export restrictions, willing to loan these talented research and development people we read about to work in a U. S. company with its good management and manufacturing capabilities and to be productive so that our mutual technology increases? My experience as a field engineer working in the Soviet Union makes me think not.

Roger Hinman
Belmont, Mass.

Money *is* power

To the Editor: I was delighted to see the introduction of logarithmic monetary notation on page 190 of the Sept. 14 issue ["Network analyzer is sensitive"]. I believe this system will go a long way toward reducing hysteria about the state of the economy; an inflation rate of less than 1 dB/year, for example, is obviously nothing to worry about. No doubt Government economists will be quick to see the virtue of this method, once logs are explained to them.

One thing puzzles me, however. I infer from the context that the formula used is:

$$dB\$ = 10 \log(value_1/value_2)$$

Does use of the constant 10 (as opposed to 20) mean that money is power?

G. Deinstadt
Ottawa, Canada

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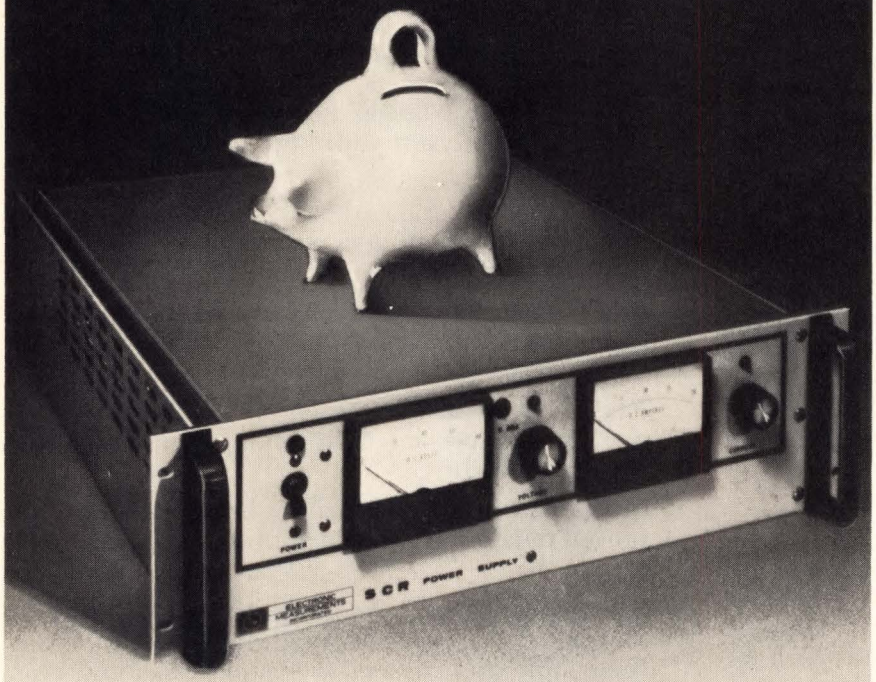

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News update

■ All's quiet on Cape Cod, at least until the Air Force issues an environmental impact statement for the Pave Paws phased-array radar installation at Otis Air Force Base. Earlier this year [*Electronics*, April 27, p. 48], the Cape Cod Environmental Coalition Inc., a group of concerned residents, tried to bring a civil suit against the Air Force to prevent it from further construction or operation of the facility until its microwave-radiation exposure levels had been judged safe.

But this move was halted early last month when the U. S. Attorney in Boston, on behalf of the Air Force, and the coalition agreed to stipulations that would:

- Permit the Air Force to finish construction on Pave Paws.
- Allow the coalition to submit any objections to the Air Force's environmental impact statement within the 45-day public-comment period that follows publication of the statement.
- Give the coalition power, within 21 days after the period ends, to file any legal and amended complaints with the courts.

The Air Force has run two series of tests—in August and October—to determine the radiation levels at various spots on the Cape; the results have shown radiation to be well below the U. S. standard for microwave radiation exposure: 10 milliwatts per square centimeter. The environmental impact statement is expected to be presented for public review late this month, and public hearings should begin in January.

Pave Paws itself would be housed in a 100-foot-high building, with most of that height on two of its sides occupied by phased arrays. To accomplish its missile-warning mission, the radar's peak output is specified at 700 kilowatts in pencil-thin beams. The average power is to be 140 kw at a frequency of 425 to 450 megahertz.

The Pave Paws program is managed for the Air Force Systems Command by the Electronic Systems division at Hanscom Air Force Base, Bedford, Mass. Raytheon Co. is prime contractor. **Pamela Hamilton**

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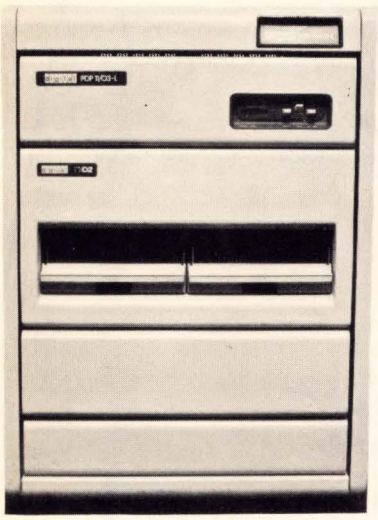

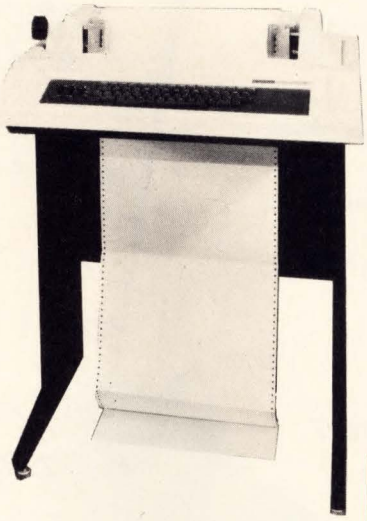

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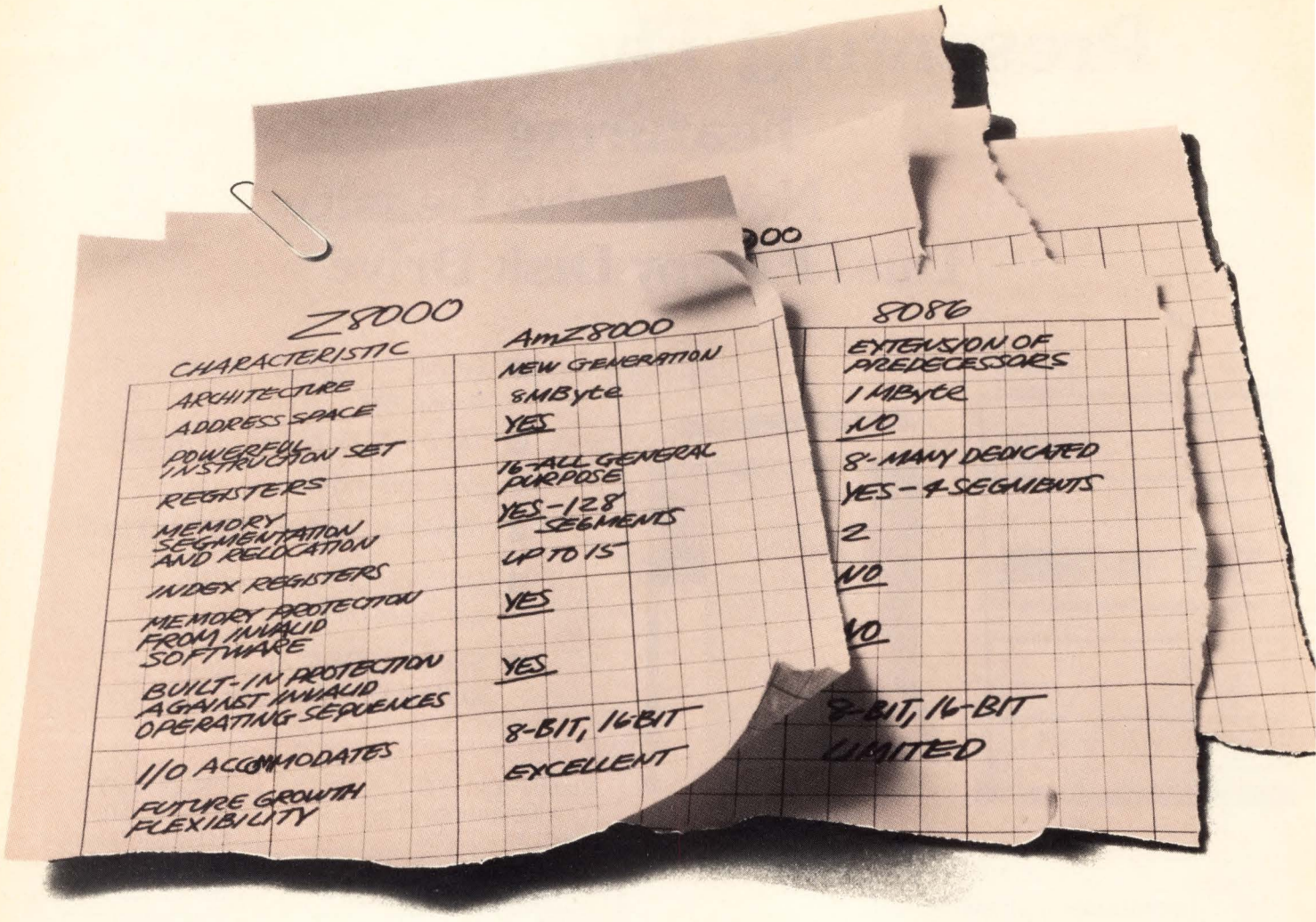

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Editorial

VLSI: opportunities and changes

In a keynote address at the Government Microcircuit Applications Conference held recently in Monterey, Calif., George H. Heilmeier, vice president of corporate research, development, and engineering at Texas Instruments Inc., took a look at some of the opportunities and challenges of very large-scale integration (VLSI). Here follow some excerpts from his speech, titled "A Review of Past and Future Innovation in Electronics Technology:"

With formidable obstacles in materials, patterning, processing, design, and test, one may wonder why the Government is interested in VLSI at all. . . .

VLSI provides us not with more of the same, but a way to circumvent these barriers. We believe that VLSI will make possible a nearly universal set of signal-processing building blocks or supercomponents [with] the following characteristics:

- They will be microprogrammable by means of on-chip read-only memory to perform specialized functions. In other words, application software will replace custom hardware. Application software is much less costly than special chip designs. . . .
- These supercomponents will be configurable in a number of different ways to achieve functions of varying complexity. Families will be compatible in terms of speed, voltages, instruction set, input/output format, etc.
- The cost, performance, and reliability will be available in data sheets so that much of the risk of custom IC development will be removed. Parts such as these, produced in large volume, will benefit from the traditional semiconductor learning curve, realizing cost and reliability benefits previously not available to low-volume custom designs. . . .

But, as powerful as this use of VLSI might be, I'd like to explore another avenue that may eventually become even more important than functionally programmable building blocks. I am referring to the synergistic relationship between VLSI technology and machine intelligence.

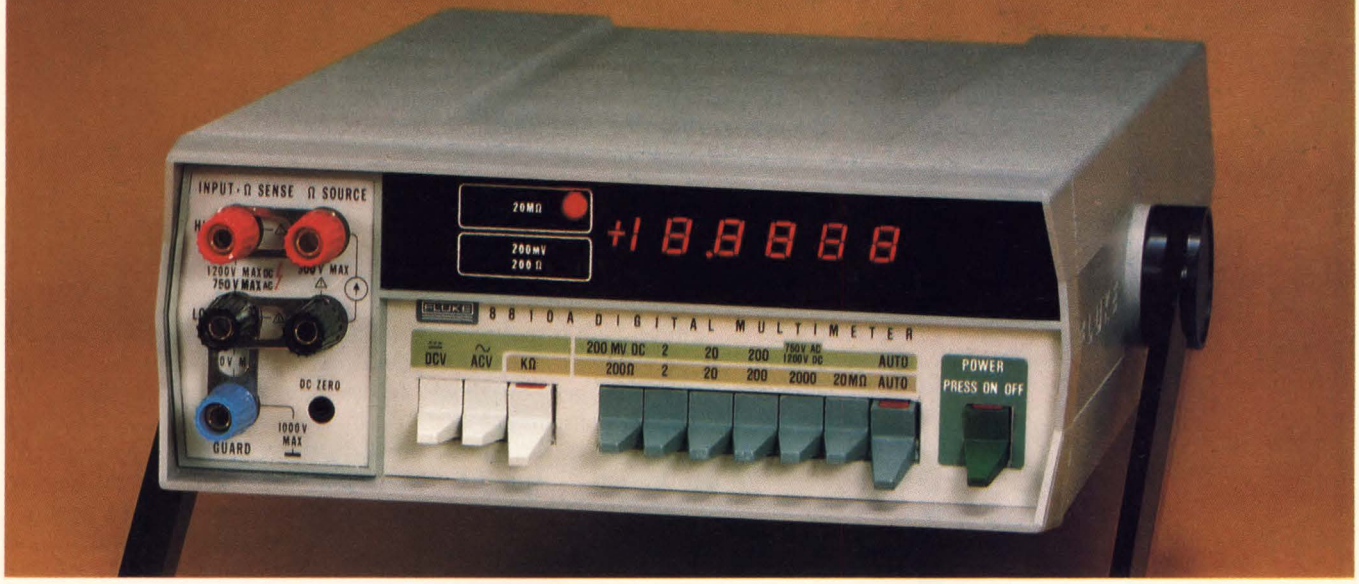
Since the dawn of the computer age, we have exploited the quantitative power of computers, i.e., the ability to "crunch numbers," and we have done this in a manner dictated by the "conservation of hardware" dogma. Well, "computational scarcity" has given way to "computational plenty." This is the key to opening the door leading to the exploitation of the qualitative power of computers to emulate human thought processes for problem solving, planning, and hypothesis formation. Quantitative computation is characterized by numerical calculations. In contrast, qualitative computation is characterized by inference and deduction. This is what we call "machine intelligence."

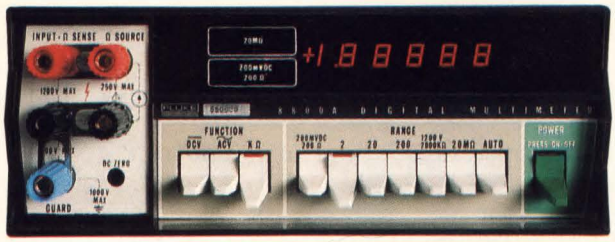
Now, what does all this mean? In machine intelligence, instead of the user relating his needs to the programmer who then writes a program in system code, the user will load rules directly into the system. . . .

Machine intelligence could mean an end to "computerese" and the beginning of an ability to verify the correctness of programs. It could mean English query-response capability for data bases . . . For example, one could ask a status-of-forces data base, "How many ships are within 100 miles of Guam?", instead of typing /**(SHIPS)100NM(GUAM), or some other mysterious combination. . . .

The pieces could be on the horizon which, when coupled to machine intelligence capability, could provide us with an opportunity to open entirely new markets . . . we must get out of the rut that says VLSI will simply make existing quantitative applications smaller, faster, and cheaper . . . VLSI is the key to the viability of machine intelligence that represents, not a straight-line projection, but a quantum jump in opportunities—and that's what innovation is all about.

HOW COULD THE INDUSTRY STANDARD 5½-DIGIT DMM BE IMPROVED?





The problem was, what could be improved? The 8800A already has made its reputation by providing the accuracy, stability and resolution usually found only in big, expensive lab instruments. And it has four-terminal ohms, 1000 MΩDC input resistance, and full guarding thrown in for good measure.

Combine all this with autoranging, extensive overload protection, and a cost effective price, and it's no wonder the 8800A is the industry's most popular bench/portable 5½-digit DMM.

It's specified for one year! You know how much money you can save by eliminating the time and expense of shorter re-cal cycles. And this kind of long-term stability is just what you'd expect from Fluke.

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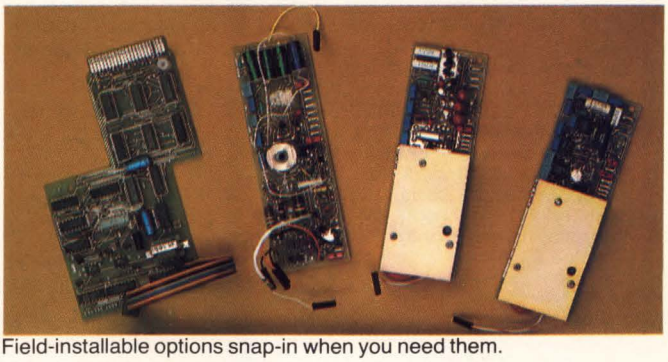

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The new OPTRON devices combine a high efficiency solution grown gallium arsenide infrared LED with a silicon N-P-N phototransistor (OPB 708) or maximum sensitivity photodarlington (OPB 709) in a molded plastic package. The photosensor senses radiation from the LED only when a reflective object is within its field of view.

With a LED current of 40 mA and with the OPB 708 positioned 0.150 inch from a reflective surface, typical output current is 50 μA for a 90% diffuse reflective surface and 1.0 mA for a specular reflective surface such as aluminum foil. Under similar operating conditions, the output current of the OPB 709 is 7.5 mA and 100 mA.

Both devices are ideally suited for such non-contact sensing applications as paper or card edge detection, motor speed controls, EOT/BOT sensing, and proximity detection.

The OPB 708 and OPB 709 as well as other low cost, high reliability reflective object sensors are immediately available from stock. Custom versions are available on request.

Detailed technical information on the OPB 708 and OPB 709 reflective object sensors and other OPTRON optoelectronic products...chips, discrete components, optically coupled isolators, and interrupter assemblies... is available from your nearest OPTRON sales representative or the factory direct.

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People

Foley's aim: a better business climate in Massachusetts

It requires a rare perspective to match the goals of the entrepreneurial chief executives of electronics companies to those of state legislators. But Howard P. Foley brings that perspective to his new job. The 40-year-old former computer marketing manager officially became executive director of the Massachusetts High Technology Council last month, although he had essentially been doing the job well before that.

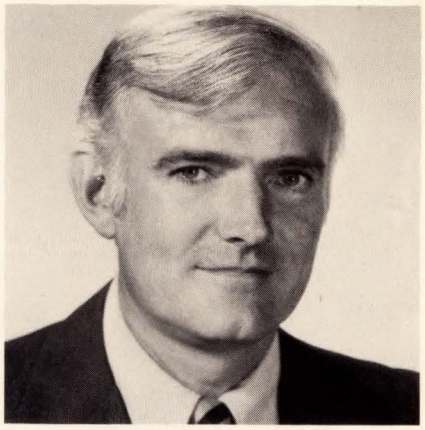
The council was formed by the chief executives of 83 companies—a major portion of them electronics firms—to improve the climate for growth in the Bay State [*Electronics*, Oct. 12, p. 90; Jan. 5, p. 112]. Foley should be a definite asset as one of just two permanent staff members. He can certainly identify with high technology, after more than 10 years in sales and marketing positions with IBM Corp.

Even more important to the council, however, the energetic Notre Dame alumnus most recently was executive vice president of Jobs for Massachusetts Inc., a nonprofit corporation he helped start in 1972 to work with Government and industry to bring more jobs to the state. "I know how to operate in the public sector," the pragmatic Foley says. "It was a hell of an education learning how the legislature operates."

Persuasion. Foley foresees no problem in getting the legislature's attention. "It's a question of whether a persuasive argument can be made to get the legislative decisions we need, given competing interests," Foley maintains. "I think we have a good shot at it because we have a unique story to tell. The companies in the council are going to create 100,000 jobs in the next four years. We just have to make sure that a fair share of them are created in Massachusetts."

How will this be done? "By the council filing and amending legislation that will focus on the 'people taxes' in the state," Foley says. These include personal income and property taxes, which, if lowered, would put the Commonwealth in a better position to compete for technical talent from other states. That won't be the council's only effort, though. It will try to change what Foley regards as an anti-business, high-tax climate in Massachusetts and launch a program to encourage students from junior high school and up to seek careers in high-technology areas.

"I'm optimistic that we can do something here," Foley says. "The ballgame isn't over, but if we can't take care of the high-technology companies, the ballgame will be over in Massachusetts." He means that most of their expansion could take place outside the state. Foley knows that changing the climate for business in the state will be a slow process, but after six years of work in the public sector, he says, "I'm still enthusiastic about this kind of work, although, as John F. Kennedy said, I realize there are no final victories."



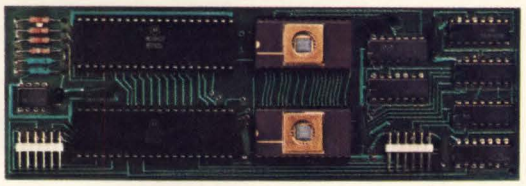
Jobs. Howard Foley wants a fair share of new high-technology jobs for his state.

Rhines to give user appeal to TI's 16-bitters

Walden C. (Wally) Rhines is a TI kind of guy, which means he truly believes that Texas Instruments Inc. is the only place to work and a six-day work week is two days shorter than it ought to be. He also believes in a 16-bit processing world, and as the new manager of TI's MOS micro-

Once you compare our new 191 digital multimeter to ordinary 5½-digit DMMs, we think you'll readily agree that it outclasses its class. For good reason.

The 191 is a ±200,000-count DMM capable of 0.004% accuracy and 1μV/1mΩ sensitivity. It delivers unsurpassed accuracy, faster, because firmware in the 6802-based μcomputer has replaced slower, less precise analog circuitry.



Displayed data is updated at the fastest rate of digit change readable by the human eye—4 conversions per second. Settling time of 0.5 seconds is easily half that of the 191's nearest competitor.

The μP combines both charge-balance and single-slope conversion techniques. Every displayed reading is automatically corrected for zero and gain drift.

If you've ever had to contend with the frustration of potentiometer zeroing, you'll appreciate the 191's null function. Automatic arithmetical correction of residual error is standard. With a touch of the button you can buck out any in-range signal, large or small.

A year from now you'll own one or wish you did.

You don't need low-level noise either. So the 191 automatically suppresses it. The 191's non-linear digital filter is entirely free of dielectric absorption and leakage problems associated with analog techniques. On the 200mV and 200Ω ranges, the filter effectively attenuates noise by displaying a running average of the 8 previous readings. Yet it instantly displays input changes of 10 digits or more.

Another exclusive of the 191 is 2 and 4-terminal measurement from 1mΩ to 20MΩ across six ranges. Simply adding two more sense leads automatically enables Kelvin measurements. No changing input terminal links or even pushbutton settings.

And, finally, since μP design reduces component count, the 191 requires less servicing and calibration, increasing reliability and stability.

At $499 without plug-in ACV, the 191 is today's performance/value leader in 5½-digit DMMs. A year from now most people will agree. But you probably don't need that much time to make up your mind. And we're ready to help you with a demonstration or additional information. Call 800-321-0560. In Ohio, 216-248-0400.

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Next year you'll be glad you did.

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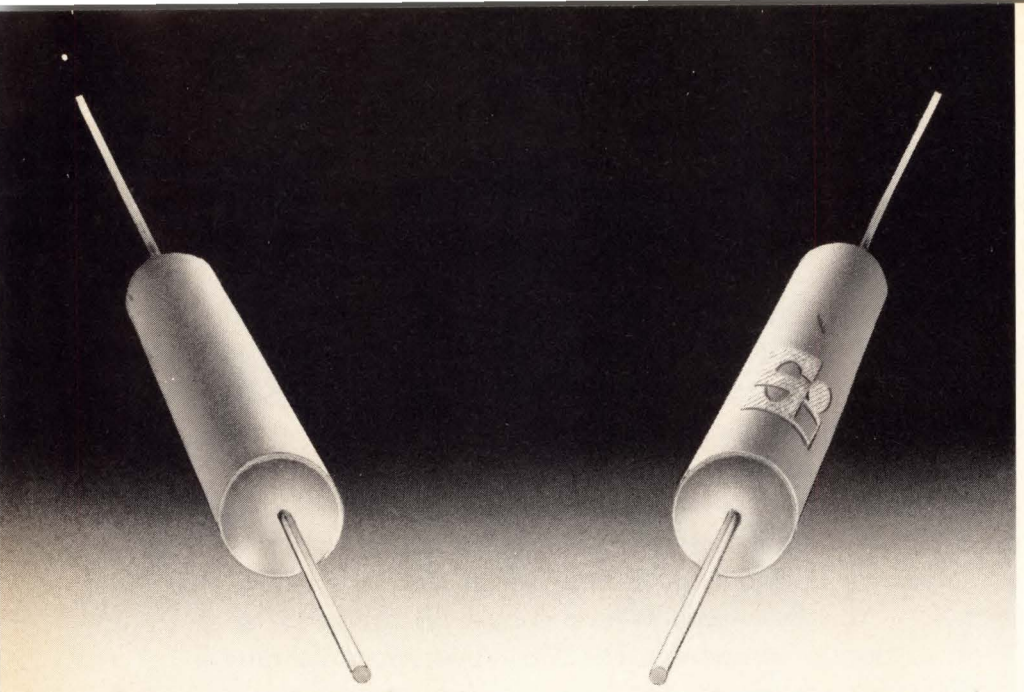

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We're not a giant and capacitors are *all* we make. No widgets, swidgets or other components. Just capacitors. So we can't afford anything but top quality and reliability. But, since everyone claims these things, we have to be very price competitive as well. We are.

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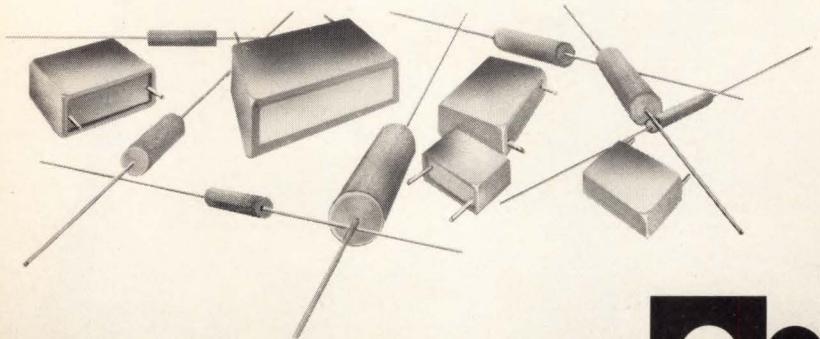


Everything in Film Capacitors

Circle 16 on reader service card

People

16-bit man. Easier-to-use software and versatile peripheral chips are keys to Wally Rhines' 16-bit microprocessor world.

computer department in Houston, he is out to convince others as well.

"Industrial control and telecommunications applications are crying for 16-bit performance," says the 31-year-old Rhines. Only six years after joining TI with a Ph.D. in materials science to develop charge-coupled devices, Rhines has been made responsible for marketing strategy and business planning for the 16-bit 9900 microprocessor and 990 microcomputer-board families. These applications need the higher precision that 16-bit processing provides for measurements and calculations, he says, and their doubled word length guarantees that they will have inherently better performance than 8-bit machines.

Slow going. Rhines admits that 16-bit devices, which were introduced about 3½ years ago, have been slow to catch on. TI, in fact, skipped an 8-bit part entirely, so sure was it that 16-bit parts would be accepted. Now Rhines speaks enthusiastically of speeding acceptance.

In large part he intends to do it by introducing cheaper and more powerful software to make the 16-bitters easier to use. Just announced, for example, is a $625 software development board for the 990 (see p. 182). He also has his eye on offering more versatile chips, ones that can be programmed for a variety of tasks. Such chips will make it easier to use the 16-bit microprocessor and help keep parts counts down, he points out. And he looks forward to other manufacturers getting into the 16-bit marketplace to add credibility to the double-precision 16-bit world. □

MEASUREMENT COMPUTATION news

product advances from Hewlett-Packard

DECEMBER 1978

System 35
Under its friendly exterior, the power of a minicomputer.

In one compact package, with fully integrated keyboard, central processor, CRT, and printer, HP's new System 35 also incorporates the largest memory capacity for its class, an extensive interfacing range, plus the first assembly language programmability ever offered in a desktop computer. Yet System 35 retains a convenience that makes all its high performance so easy to use, even for a beginner.

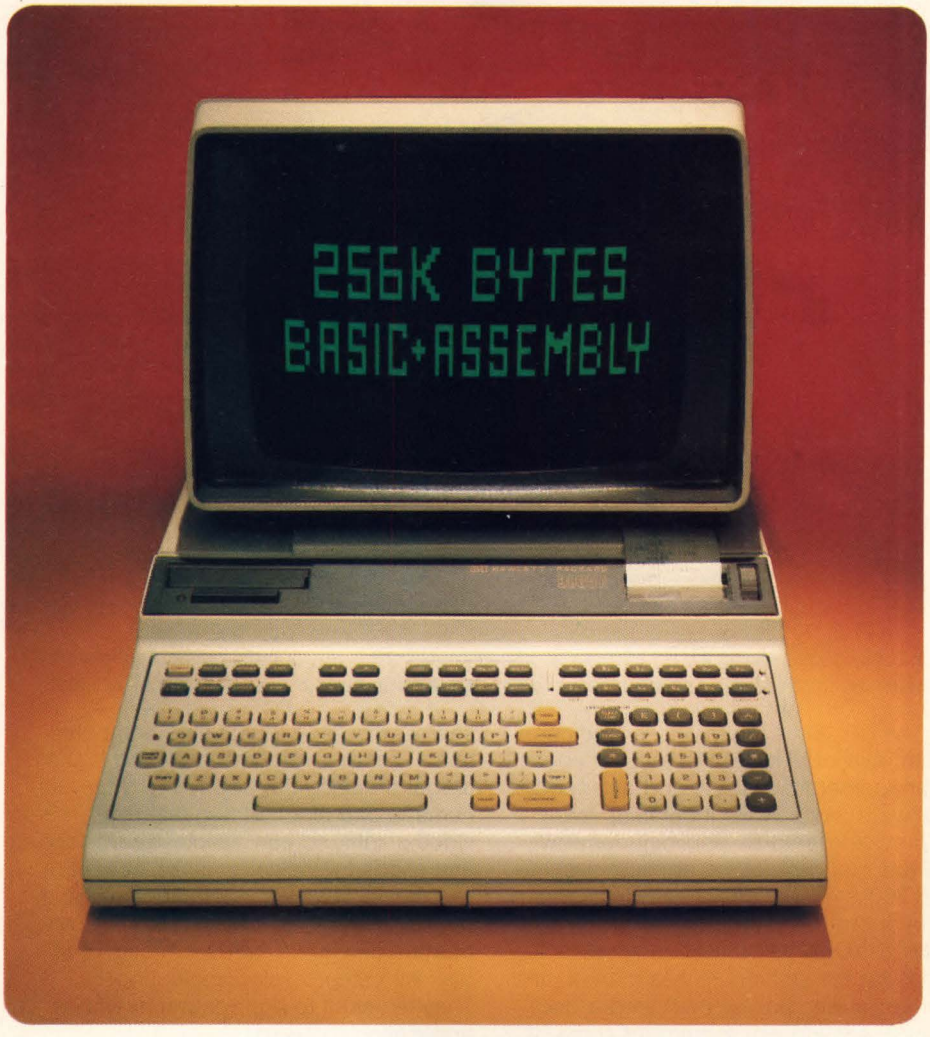
Available with or without a CRT or printer, System 35 fills a growing need in engineering and scientific applications, as well as in OEM systems, for a mid-range, large-memory desktop computer. In fact, application areas formerly served primarily by minicomputers can now look to the System 35 for their data acquisition and control tasks. Several important System 35 features contribute to this:

Language is power and speed

Besides enhanced BASIC, System 35 offers optional assembly programming. Simple to learn and use, enhanced BASIC has many powerful and convenient features of FORTRAN, including subprograms, multidimensional numeric and string arrays, plus multicharacter identifiers.

For special applications, the assembly-level programming by skilled programmers provides complete access to the

(Continued on third page)



HP's successful mating of high performance and ease of use has resulted in a versatile, advanced desktop computer—the System 35. Not much larger than an electric typewriter, it can sit on your desk or be moved to the laboratory or production department to acquire and analyze data or control instruments and machinery.

HP-IB

IN THIS ISSUE

Hi-accuracy modulation analyzer • Advantages of fiber optic link • Low cost, computing counter

This new, easy-to-use, small business computer with true data base management adapts to your existing organization

As a further convenience, the HP 250 can be placed in most office environments without special site preparation. Installation is a simple matter of plugging the computer into a standard electrical outlet.

The HP 250 is the lowest-priced computer available today with full data base management capability and extensive software tools. While it contains many big-system features, and includes powerful tools for developing applications; the HP 250 is exceptionally easy to program and operate. It is well suited for the end user, the OEM who tailors computer solutions for the small-business market, and for larger companies that need a dedicated, easy-to-use system for some of their departments.

User Convenience

Careful attention to human engineering has produced a system that reflects the way people like to work and that does not seem formidable to first-time computer users. For example, the keyboard is like that of an electric typewriter and the numeric pad of an adding machine. The video display screen, which swivels, tilts, and slides for viewer comfort, has eight "soft keys," with definitions labeled on the display screen. These keys can be programmed to guide the user through each task with step-by-step prompting. They're useful to a programmer writing application software.

The HP 250 hardware is a state-of-the-art 16 bit N Channel MOS microprocessor which handles computation with 12-digit accuracy. The entire operating system is loaded from flexible discs into its own internal memory space. Thus, it is always on-line, ready for instant use.

Business Basic

Programmable in an enhanced version of HP BASIC, the HP 250 also has subprograms, string manipulations, and six-dimensional arrays.

Data Base Capability

To give the user full access to organized information rather than unrelated data, the HP 250 software provides complete data base management capability. IMAGE/250 is a collection of utilities and commands that create, control, and maintain a complex information management system with full security.

QUERY/250 facilitates free form, authorized, unprogrammed access to stored information. Its frequent prompts assist inexperienced users in retrieving, updating, or modifying data.

User Forms on Screen

FORMS/250, another software convenience, makes it easy to put the user's existing business forms on the HP 250's display screen for fill-in-the-blanks use.

Create a Report

REPORT WRITER/250 gives the user a versatile set of commands to generate final, professional-looking reports.

The HP 250 also has up to 256k bytes of main memory built into the attractive desk-style unit. Through flexible or fixed discs, storage can be expanded to 40 megabytes. The user also no longer has to be concerned with whether the system is in good operating order; it automatically tests itself whenever it's turned on. The CPU and memory boards are on a single roll-out chassis for easy access. The HP 250 system includes two 1.2 megabyte flexible disc drives, a dot matrix printer, the data base manager, and all the application tools described.

Send for more complete information on the HP 250 by checking ***B*** *on the HP Reply Card.*

HP calculator accessories—exceptional holiday gifts

To complement the growing number of HP personal calculators used in scientific and business environments, Hewlett-Packard manufactures a wide range of accessories. Each accessory item is designed to increase the convenience and versatility of these calculators.

Battery Packs for all models.

Reserve Power Packs to keep a spare battery pack fully charged.

Recharger/AC Adapters for added convenience. Dual voltage models for the international traveler.

DC Adapter/Rechargers let you recharge your calculator in a car, boat, or plane.

Soft Cases, some in elegant black leather with belt loop.

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Security Cradles and Cables secure your calculator against pilferage.

Application Pacs for 10 different fields provide fully-documented programs, prerecorded on magnetic cards.

Solution Books contain the fastest and best solutions for most-used applications in more than 40 different fields.

Blank Program Cards let you write and preserve your own programs.

Printing Paper for all printing models.

*Whether considering accessories as a gift or for your own HP calculator, send for detailed information by checking **A** on the HP Reply Card.*

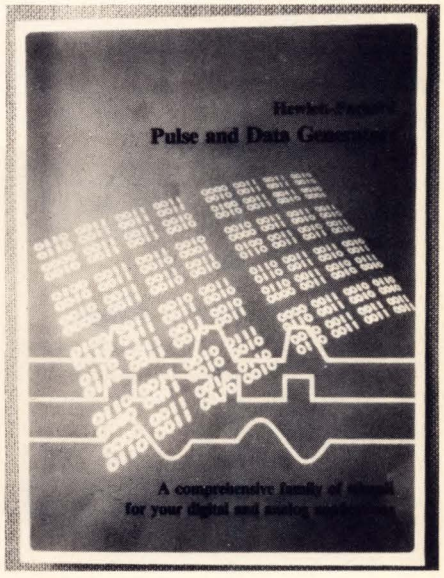
A quick way to select HP pulse and data generators for your specific needs

For those seeking a lucid survey of stimuli for logic and general-purpose applications, a new brochure **Pulse and Data Generators** from HP will be compelling reading.

A four-page, full-color spread provides a good view of signal sources within HP's extensive line and an informative presentation of the product capabilities. Whatever your need, the brochure covers it from inexpensive instruments for simple tasks right up to high performance models offering the sophistication of HP-IB programmability and μP comfort.

Selection charts containing leading specifications offer a quick means of locating your special interest whether by logic family, frequency range, programmability, or other features of prime concern.

*Check **D** on the HP Reply Card for a complimentary copy of this brochure.*



System 35 offers read/write memory up to 256K bytes and assembly language programming

(Continued from first page)

System 35's central processor and can increase speed by a factor of 100 or more. A set of optional ROM's provides access to the assembly language for writing, debugging, and running.

Big memory

The Read/Write memory ranges from 64K bytes to 256K bytes. At the maximum level, a System 35 can manage an array of over 30,000 12-digit floating-point numbers.

I/O Versatility

System 35's I/O versatility makes it the solution for many data acquisition and control problems. It offers buffered I/O, Direct Memory Access, 15 levels of priority interrupt, built-in I/O drivers, and ready-made interface cards. These plug-in cards facilitate interfacing the system with up to 14 peripherals and instruments simultaneously. The cards are the HP-IB, Bit-Parallel, Bit-Serial, BCD, and a Real-Time Clock.

*We have much more to tell you about this product so check **C** on the HP Reply Card for all the details.*

New modulation analyzer replaces bench full of instruments, provides easy, accurate transceiver testing

HP-IB

Testing the transmitter portion of transceivers has usually involved a bench full of general purpose equipment, such as frequency counter, power meter, modulation meter, distortion analyzer, perhaps a scope, spectrum analyzer, voltmeter, and more.

Now HP introduces the 8901A Modulation Analyzer which in a single unit combines the capabilities of many such instruments to thoroughly characterize the transmitter RF frequency, power, and modulation performance over the 150 kHz to 1300 MHz range.

Broad Application Range

It is designed for manufacturers and users of AM, FM and ΦM transmitters with a broad application range including maritime, broadcast, avionic communication and navigation aids, mobile FM, and military tactical. It should also find considerable use by metrology laboratories in calibrating signal generator workshops.

Ease of Operation

A precision, calibrated receiver, the 8901A is microprocessor-based, so even in the manual mode, most measurement sequences can be executed with a single keystroke. For example, AUTO-FREQUENCY causes the instrument to sweep the entire 150 kHz to 1300 MHz range and go back and lock onto the strongest signal, digitally displaying frequency with 10 Hz resolution to 1000 MHz, 100 Hz beyond. If the desired signal is weaker, a second tuning mode uses the keyboard to set the approximate frequency for lock-on. The 8901A thus becomes a frequency-selective counter.

The 8901A measures RF power at the input from 1 mW to 1 watt. The technique responds to peak envelope power, very important for amplitude signals. An input power overload circuit protects for signals up to 25 watts. By selecting TUNED RF, the unit measures power in the IF passband and becomes a selective power meter.

Accuracy

AM, FM, and ΦM modulation measurements are very accurate with a general accuracy of ±1% over many ranges. In the important avionic navigation frequencies, AM accuracy can typically achieve 0.5%.

Because there is good AM-FM detection circuit isolation, combined modulations are easy to separate. Incidental AM, FM or ΦM can be measured even in the presence of large values of primary modulation.

Both positive and negative peak detectors are available along with a peak hold function. Internal selectable lowpass and highpass filters along with 4 de-emphasis filters of 25, 50, 75 and 750 μs allow the 8901A to simulate typical receiver operation, such as FM mobile.

Internal Calibrator

An internal calibrator option is offered to generate precisely modulated AM and FM signals with ±0.1% accuracy for use as calibration standards. With this option, more measurement confidence can be obtained on the production line or in remote applications such as flight line or broadcast signal analysis.

AM measurement range is up to 100 kHz and up to 99%. FM capabilities go to 200 kHz rates and up to 400 kHz peak deviations for frequencies from 10 MHz to 1300 MHz. Phase modulation measures rates to 20 kHz and peak deviation to 400 radians, depending on rate.

Most displayed measurements can be presented either as the measured quantity, or as a ratio in percent or dB referred to a previously measured number or to a keyed-in number. In addition, a large number of "special" key functions provide for selecting internal functions, "freezing", auto-ranging, or for service and maintenance diagnostics.

The Hewlett-Packard Interface Bus is included as a standard feature to allow fully automatic operation under control of a desktop computer, or in distributed production operations.

*Check **E** on the HP Reply Card for more information.*

Three new interface boards greatly simplify computer system analysis

Shown here is an HP 1027A PDP-II UNIBUS Interface on an extender board plugged into a minicomputer for tests with a logic analyzer. Also shown is a 10277A (on the 1610A logic analyzer) general purpose interface which interconnects through probe pod "buckets" and two 40-pin ribbon connectors.

Though logic analyzers have proven to be very valuable tools in assessing and viewing computer system performance, obtaining physical access to computer buses has, until now, involved many lengthy and complex connections.

Now, HP introduces three new interface boards which significantly simplify and speed the connection between computer and logic analyzer to let you solve state flow problems and analyze handshake operations while lowering testing costs.

Simply plug an interface board into the computer, connect the analyzer, and in moments you'll have an easy-to-interpret display of state flow including address, data or control line activity, or the time interval between specific bus-arbitration steps and handshake operations.

One of the three interfaces, the Model 10277A/B/C is a General Purpose Probe Interface which conveniently connects logic analyzers to digital systems through two 40-pin ribbon connectors. Two of the new interfaces, Models 10275A and 10276A, connect directly to Digital Equipment Corporation's minicomputers.

The 10277A/B/C interface is available for HP analyzers: the 1610A, 1615A, 1600A, or 1607A. A removable board in these interfaces contains wire wrap pins, allowing the user to define which system signals are supplied to the analyzer.

A PDP-11 UNIBUS* interface, the 10275A, plugs directly into the PDP-11 small peripheral control slots to access all 56 signals on the bus. The LSI-11, Q-BUS* interface, Model 10276A, also plugs directly into an LSI-11 minicomputer. Switches on these interfaces provide qualification of bus activity so that reads, writes, interrupt vectors, refresh activity, or DMA transfers can be selectively captured or excluded for detailed analysis.

*Check **F** on the HP Reply Card for details.*

*Trademark Digital Equipment Corp.

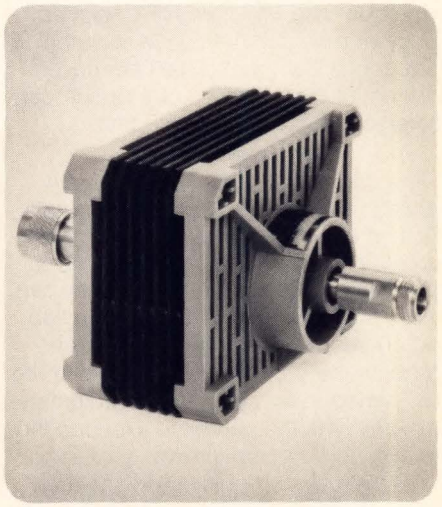
25-watt coaxial attenuators now available to 18 GHz

For broadband coaxial measurements at medium power, Hewlett-Packard now offers a new 30-dB attenuator, the HP 8498A, which covers the DC - 18 GHz frequency range.

One of the primary features of the 8498A is that the attenuator pad is designed to be bilateral, with either end able to accept 25-W input. The standard connector configuration uses one Type N male and one Type N female, so adapters are not needed for direct connection to high power. SWR is <1.28 at 18 GHz.

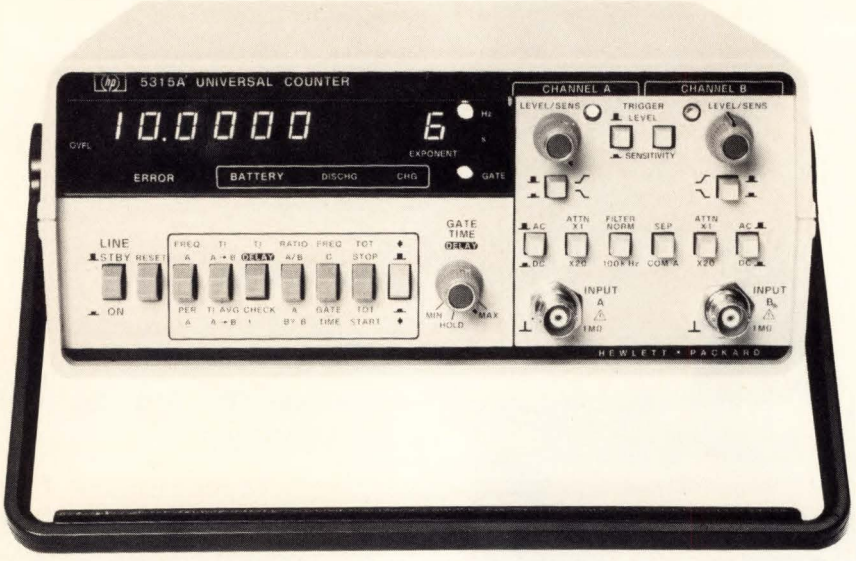
The 8498A design provides efficient heat dissipation with cooling fins which remain cool to the touch even during operation at 25 watts. Thus, reconnections can be made without waiting for the unit to cool down.

*Check **G** on the HP Reply Card for details.*



25 watt attenuator can accept input power on either connector.

Hewlett-Packard revolutionizes the portable universal counter



All frequency measurements can be made to at least 7 digits of resolution in one second of gate time with this new, computing universal counter from HP. This counter also allows period measurements to be taken to 100 MHz without any loss of resolution.

The HP 5315A 100 MHz Universal Counter is the world's first computing (reciprocal) counter for under $1,000.

Compact and easy to carry for field use, the 5315A has all the quality and capabilities you would expect of a top quality but more expensive universal counter, including 100 MHz direct frequency counting, period, period average, 100 nsec time interval average, ratio, totalize, as well as 10 Mv sensitivity to 10 MHz.

Just three digital IC's, a single chip microprocessor, an integrated display driver, and a Multiple Register Counter (MRC), yield at least 7-digits of resolution per second via reciprocal (period taking) technique. The MRC, an HP-designed LSI chip, provides the 5315A with the data acquisition capabilities needed to perform all the functions of a reciprocal universal counter in a single chip.

User Conveniences

The computing ability of the 5315A provides a number of user conveniences. The first is a continuously variable gate control. No longer are you restricted to gate times in decade steps. Now, you can select any gate time between 50 msec and 10 seconds and the counter will compute the correct resolution. As a result, period averaging is done automatically any time the gate time exceeds the input period. In time interval averaging, the statistically insignificant digits associated with this mode of measurement are, again, automatically truncated for a clutter-free display. To further improve display readability, the microprocessor formats all measurement results in familiar engineering notation and presents them on eight .3" amber LED's.

Optimized Signal Conditioning

The input signal conditioning of the 5315A has been optimized for both frequency and time interval measurements. For frequency, there is AC/DC coupling, a sensitivity control, and a switchable low pass filter. For precise time interval measurements, there are tri-state trigger lights, trigger level controls, separate/common switch, and X1/X10 attenuators.

To help make time interval measurements on noisy signals such as relays, time interval delay is provided. This feature allows the relay associated "chatter" to be ignored by the 5315A. Delay, or hold-off time is set via the gate/delay control on the front panel, one of several controls that serves a dual purpose.

Built with RFI in mind, the 5315A passes VDE 0871-0875 Level A limits for electromagnetic compatibility in the plastic package. For more stringent requirements, the 5315A is available in a rack/stack metal box as the 5315B, which passes MIL STD 461.

*For additional information, check **H** on the HP Reply Card.*

Signature analysis cuts dealer service costs

Hugin Kassaregister of Sweden has the world's second largest installed base of mechanical cash registers, supported by a strong dealer service network. When they introduced their first μP-based product, they faced the major task of retraining their highly-skilled, but mechanically-oriented field service personnel.

Hugin engineers retrofit their product for component-level repair, using signature analysis (S.A.) and are experiencing:

Lower Training Costs. Existing personnel can use S.A., without lengthy upgrading to an electronic technician level.

Lower Equipment Costs. Service requires only Hewlett-Packard's low-cost, portable 5004A Signature Analyzer, instead of a bench full of test equipment.

Faster Repair Times. Most bad IC's are located in less than 15 minutes.

Lower Inventory Costs. Dealers need to stock only small parts, instead of entire boards or extra cash registers.

Actual Hugin experience shows that dealers save $50.00 per repair with S.A.. With that saving alone, they can pay off a 5004A Signature Analyzer in one year, with an installed base of only 20 registers.

*Can signature analysis make your field service operation more efficient? To find out, check **I** on the HP Reply Card.*

Dealer service personnel troubleshoot Hugin microprocessor-based cash registers to the component level with Hewlett-Packard's 5004A Signature Analyzer.

HEWLETT-PACKARD COMPONENT NEWS

HP's new, complete fiber optic link offers many advantages in digital data transmission

A new, complete fiber optic link for data communications applications that requires no expertise in optical design, calibration, or adjustment is available from Hewlett-Packard.

A low error rate fiber optic link, the new HFBR-0010 system makes the use of fiber optics simple and practical for a broad range of customers. It comes ready to hook up, and consists of a digital transmitter, a digital receiver, a single fiber 10-metre connector/cable assembly and complete technical literature. Each of the components is available separately, and the connector/cable assemblies come in five standard lengths, with a maximum distance of 100 metres.

Broad Application Range

Typical applications of the new link include: large computer installations; distributed processing systems; hospital computer systems; power plant communications and control; process control; secure communications; aircraft or shipboard data links; high voltage or electromagnetic field research; remote instrumentation systems; and factory data collection.

Using fiber optic techniques, digital information is carried via light waves instead of electronic signals using traditional methods. Benefits include immunity to electromagnetic interference; lack of radiated signal; absence of electrical path between terminals; light weight and flexibility; and broad bandwidth over long distances.

System Features

- Transmitter and receiver packages can be mounted easily on miniature PC boards.
- Standard TTL electrical interfaces.
- Single, five-volt power supply requirement.
- Unique "link monitor" built into the receiver IC to warn when information flow is interrupted.
- Signal processing that allows freedom from data formatting in transmitting information from dc to 10 megabits per second.
- An automatic "level control" that frees the user from continually adjusting the transmitted signal by adjusting the receiver amplifier gain over a 23-dB range.

HP's new fiber optic system allows digital information to be transmitted over short to intermediate distances, with many advantages over traditional electronic signal methods.

Delivery of HFBR-0010 is stock from any Hewlett-Packard franchised distributor.

*For more information, check **J** on the HP Reply Card.*

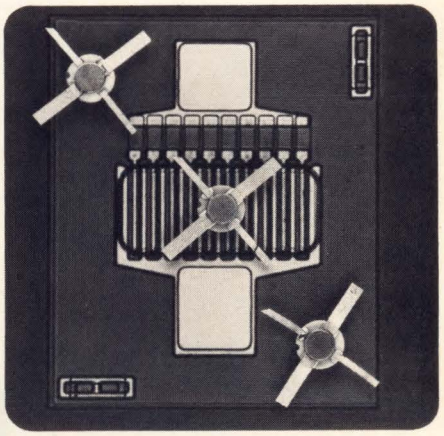
Lower your system costs with new linear power microwave transistor

The HXTR-5103 is a new silicon bipolar transistor offering designers superior power, gain, and distortion performance up to 5 GHz.

Its guaranteed power at 1 dB gain compression of 22 dBm and associated gain of 10 dB at 2 GHz commend it for use in RF and IF applications in radar, ECM, space, plus other commercial and military applications where fewer stages and simplified amplifier designs mean lower system costs.

For stripline applications, this competitively-priced device is available in the industry-standard, metal/ceramic, hermetic HPAC-200 package made popular in such microwave transistors as HP's 35821E and 35831E (Option 005).

*For more information, check **K** on the HP Reply Card.*



With excellent uniformity and reliability, this linear power microwave transistor has a typical power-added efficiency of 34%.

New low cost multifunction synthesizer

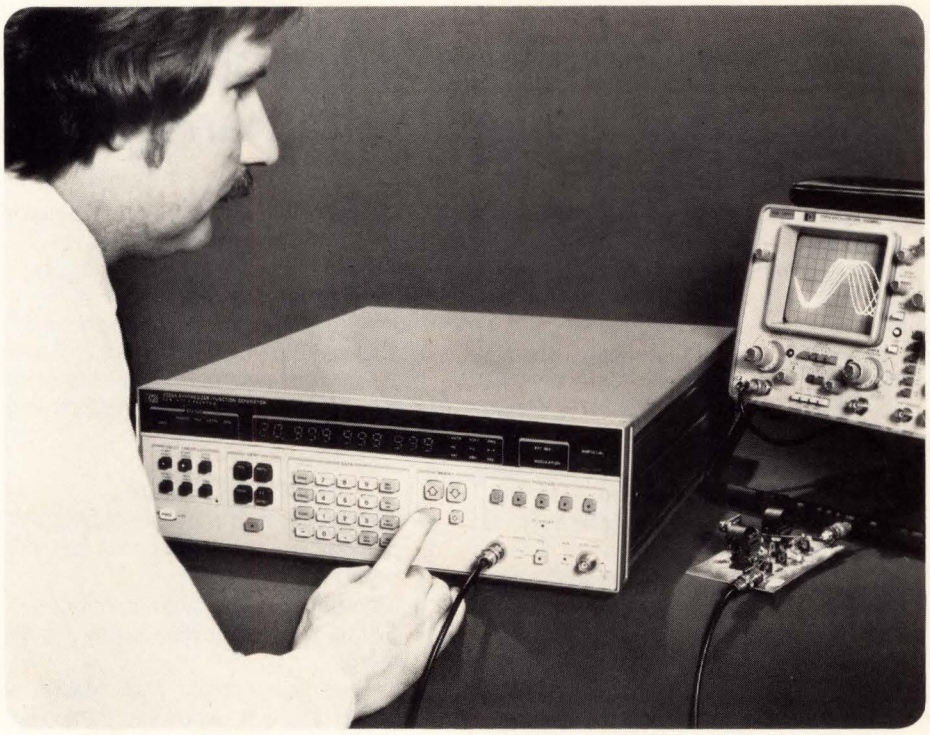
Designed for general purpose laboratory and production use, HP's new 3325A is a programmable synthesizer, function generator, and sweeper. It can be manually or automatically controlled to generate sine waves, triangles, square waves, and ramps, including sweep. Ten different instrument settings may be stored in separate memory registers for later recall. These are: frequency, function, amplitude, dc offset, phase offset, sweep start/stop frequency, sweep time, AM and PM modulation, and marker frequency.

As a **synthesizer**, the HP 3325A delivers precision sine waves from 0.000001 Hz to 21 MHz, with 11 digits of resolution. Because the 3325A is designed with one phase-lock loop instead of several, greater resolution and lower manufacturing costs result.

As a **function generator**, the 3325A generates square waves, from 1 μ Hz to 11 MHz.

As a **sweep generator**, the 3325A sweeps sine, square, triangle, and ramp functions both logarithmically and linearly, up to the full frequency range.

Frequency for all functions can be selected digitally from the 3325A front panel, or by remote control from the HP-IB (IEEE-488). All outputs, including bus handshake, are shown on front panel LED indicators.



The 3325A provides unprecedented performance per dollar thanks to several major HP technological advances. One, the single loop fractional-N synthesis technique allows synthesizer accuracy with 11 digits of resolution and phase continuous frequency sweep.

HP-IB

*To get the full specifications on this product, check **L** on the HP Reply Card.*

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HEWLETT hp PACKARD

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product advances from Hewlett-Packard

November/December 1978

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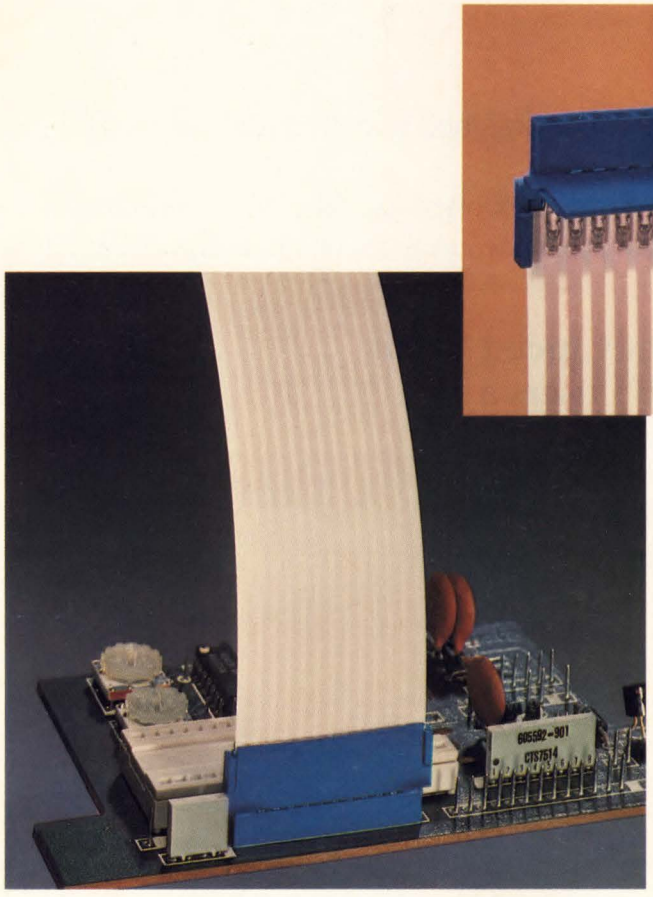
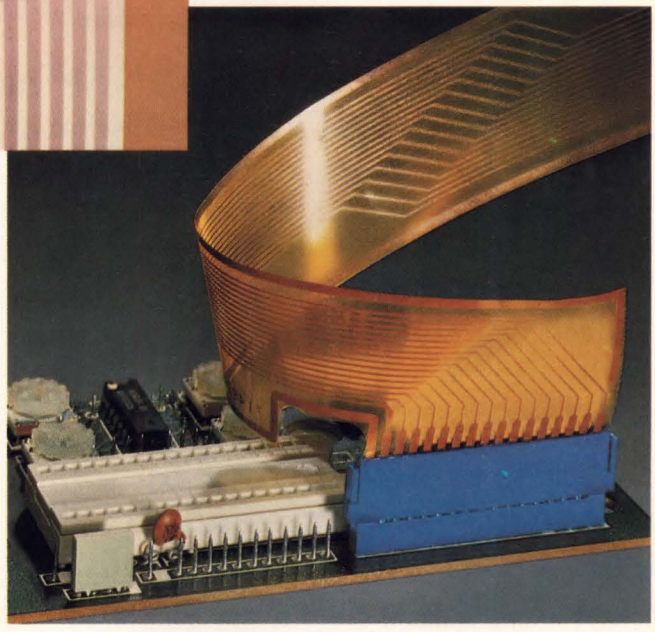
Berg's Clincher* connector mass terminates flat conductors quickly and reliably.



The "Clincher" on flat conductor, flat cable.



The "Clincher" on flat conductor, flex circuitry.

The "Clincher" is a superior connector system for flat conductor, flat cable or flex circuits. It offers high reliability and the lower applied cost of mass termination.

With the "Clincher," all of the flat conductors are terminated simultaneously, within 15 seconds. Cable stripping is not required. The "Clincher" system offers a substantial reduction in total installed cost over individually terminated conductors.

The "Clincher" design uses Berg's proprietary PV* receptacle, a connector of proven reliability for over a decade in data processing and telecommunications applications. The dual-metal construction of the "PV" provides a high normal force to assure highly reliable mechanical and electrical performance.

Berg's "Clincher" accepts a 1 to 2 oz. copper 0.062" wide cable. It is stackable on 0.100" centers in double-row configurations for dense packaging. The "Clincher" mates with 0.025" pins or standard Berg headers to form a complete interconnection system.

Rely on Berg for quality performance to meet your most demanding application needs. For a brochure describing the "Clincher" system, write or call:

The Du Pont Company, Berg Electronics Divison, New Cumberland, Pennsylvania 17070.
Telephone: (717) 938-6711.

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From CPU to software, It's the beginning of a new

Intel's new 16-bit microcomputer is here. It's the 8086, designed to deliver ten times the processing power of our 8080.

More important, right now you can get CPU, memory, peripherals, software, development tools and design assistance. We've made MCS-86™ the most comprehensive microcomputer system ever introduced.

Our challenge was to build the most advanced 16-bit microcomputer. And to give 8080 and 8085 users a direct upgrade path. We accomplished it. The 8086 is the world's most advanced microprocessor. Yet it's a direct evolution of our 8-bit 8080 and 8085. It's software-compatible with both, supporting all their instructions in addition to its own advanced instructions. And the 8086 utilizes readily available Intel microcomputer peripheral chips and low cost, standard MOS memory.

8086 is an architectural triumph, etched in HMOS. The standard 8086 delivers 5 MHz speed. And it delivers direct addressability to a full megabyte of memory, with both 8-bit and 16-bit signed or unsigned multiply and divide in hardware. It gives you efficient byte-string operations and improved bit manipulation. Plus it provides capabilities never before supported by a microprocessor, such as dynamic relocation, reentrant code, position-independent programs and instruction look-ahead.

All in all, 8086 sets a new standard for microcomputer processing capabilities.

We designed MCS-86 for design flexibility. It can operate on a full set of 16-bit registers, or on an 8-bit subset which corresponds to the 8080 register set. That makes MCS-86 adaptable to traditional 8-bit applications as well as larger, more complex applications.

A minimum MCS-86 configuration includes only the CPU, the 8284 Clock Generator, two 8282 Octal Latches, 2K bytes of 2142 RAM and 4K bytes of 2716 EPROM.

MCS-86™ is here today. era in microcomputers.

For easy expansion, add our 8288 Bus Controller, which generates Multibus™ timing signals. And, using our 8286/8287 Octal Transceivers, MCS-86 interfaces with larger, buffered systems.

Get started with software now using our Intellec® development system and PL/M 86, an expanded version of our popular PL/M high level language. And, with the ASM 86 assembler, you can write assembly language programs for your MCS-86 designs and translate your existing 8080 and 8085 software to run on 8086. Both PL/M 86 and ASM 86 operate under ISIS-II, Intellec's advanced operating system.

MCS-86 components are available today. Order your MCS-86 Prototype Kit from your local Intel distributor. The kit includes all the essential components to begin your evaluation of this new era in microcomputers. Or, for more information, contact your local Intel sales office or write: Intel Corporation, 3065 Bowers Avenue, Santa Clara, California 95051.

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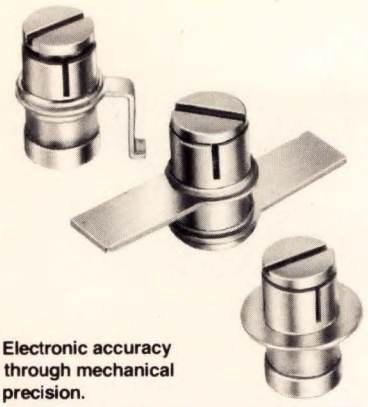

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Giga-trim (gigahertz trimmers) are tiny variable capacitors which provide a straightforward technique to fine tune RF hybrid and microwave circuits into proper behavior. They eliminate abrasive trimming and time consuming cut and try adjustment techniques, and trimming by interchange of fixed capacitors.

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- ☐ Impedance matching of GHz transistor circuits
- ☐ Interstage coupling
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Meetings

Third Biennial University/Industry/Government Microelectronics Symposium, IEEE, Texas Tech University, Lubbock, Texas, Jan. 3–4.

Modern Data Communications Seminar, George Washington University, Washington, D. C., Jan. 3–5

Microprocessor Programming Course, IEEE Continuing Education Program, Albuquerque Inn, Albuquerque, N. M., Jan. 4–6.

Winter Consumer Electronics Show, Electronic Industries Association, Las Vegas Convention Center, Las Vegas, Nev., Jan. 6–9.

17th Conference on Decision and Control, IEEE, Islandia Hyatt House, San Diego, Calif., Jan. 10–12.

Radar Signal Processing Seminar, George Washington University, Washington, D. C., Jan. 15–19.

Fourth Automated Testing for Electronics Manufacturing Seminar and Exhibit, Benwill Publishing Corp. (Boston), Marriott Hotel, Los Angeles, Jan. 23–25.

Conference on Reliability and Maintainability, IEEE, Shoreham Americana, Washington, D. C., Jan. 23–25.

Communication Networks Conference & Exposition, The Conference Co. (Newton, Mass.), Sheraton Park Hotel, Washington, D. C., Jan. 30–Feb. 1.

Microelectronics Measurement Technology Seminar/Exhibit, Benwill Publishing Corp. (Boston), Hyatt House, San Jose, Calif., Feb. 6–7.

Wincon—Aerospace & Electronic Systems Winter Conference, IEEE, Sheraton Universal Hotel, Los Angeles, Feb. 6–8.

Phase-Locked Loops Seminar, George Washington University, Washington, D. C., Feb. 12–13

International Solid-State Circuits Conference, IEEE, Sheraton Hotel, Philadelphia, Feb. 15–17.

Intelcom 79—Second International Telecommunications Exposition, Horizon House International (Dedham, Mass.), Dallas Convention Center, Dallas, Feb. 26–March 2.

Sixth Energy Technology Conference and Exposition, Electric Power Research Institute (Palo Alto, Calif.), Sheraton Park Hotel, Washington, D. C., Feb. 26–28.

Nepcon West 79, Industrial and Scientific Conference Management Inc. (Chicago), Anaheim Convention Center, Anaheim, Calif., Feb. 27–March 1.

Digital Encoding and Processing of Voice and Video Seminar, George Washington University, Washington, D. C., Feb. 27–March 1.

ICE 79—International Computer Expo, Marcom International Inc. (Tokyo) and Golden Gate Enterprises Inc. (Sunnyvale, Calif.), Tokyo Harumi Fairgrounds, Tokyo, Feb. 28–March 2.

Optical Fiber Communication Meeting, IEEE and Optical Society of America, Shoreham Americana Hotel, Washington, D. C., March 6–8.

12th Annual Simulation Symposium, IEEE, Causeway Inn, Tampa, Fla., March 14–16.

Fifth Annual Conference and Exhibit on Industrial and Control Applications of Microprocessors, Information Gatekeepers Inc. (Brookline, Mass.), Sheraton Hotel, Philadelphia, March 19–21.

Technical Symposium East '79, Society of Photo-Optical Instrumentation Engineers (Bellingham, Wash.), Hyatt Regency Hotel, Washington, D. C., April 2–5.

27th Annual Relay Conference, National Association of Relay Manufacturers (Elkhart, Ind.), Oklahoma State U., Stillwater, April 23–25.

How you can get Z80 power for $171.

Mostek's MD Series™ lets you control system functions and cost.

Design Z80 systems fast and economically with Mostek's MD Series of OEM microcomputer boards. Choose either MD stand-alone boards or expandable MDX boards—both on compact 4.5″ x 6.5″ cards.

Mostek's Micro Design Series

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*100 lot quantities

The MDX boards are modularized by function. This reduces system cost since you buy only the functional modules you need. And you can use any combination of MDX cards because all MDX cards are STD BUS compatible.

The STD BUS is a unique second-sourced motherboard interconnect system designed to handle any MDX card in any card slot. This reduces hardware design time letting you concentrate on application software.

The MD stand-alone microcomputer boards are also Z80-based. The MD-SBC1 features 8K x 8 EPROM; 2K x 8 RAM; two 8-bit input ports; three 8-bit output ports; two interrupt inputs; and single +5 Volt power supply.

For more information, call or write Mostek, 1215 W. Crosby Rd., Carrollton, TX 75006; phone 214/242-0444. In Europe, contact Mostek Brussels; phone (32) 02/660.25.68.

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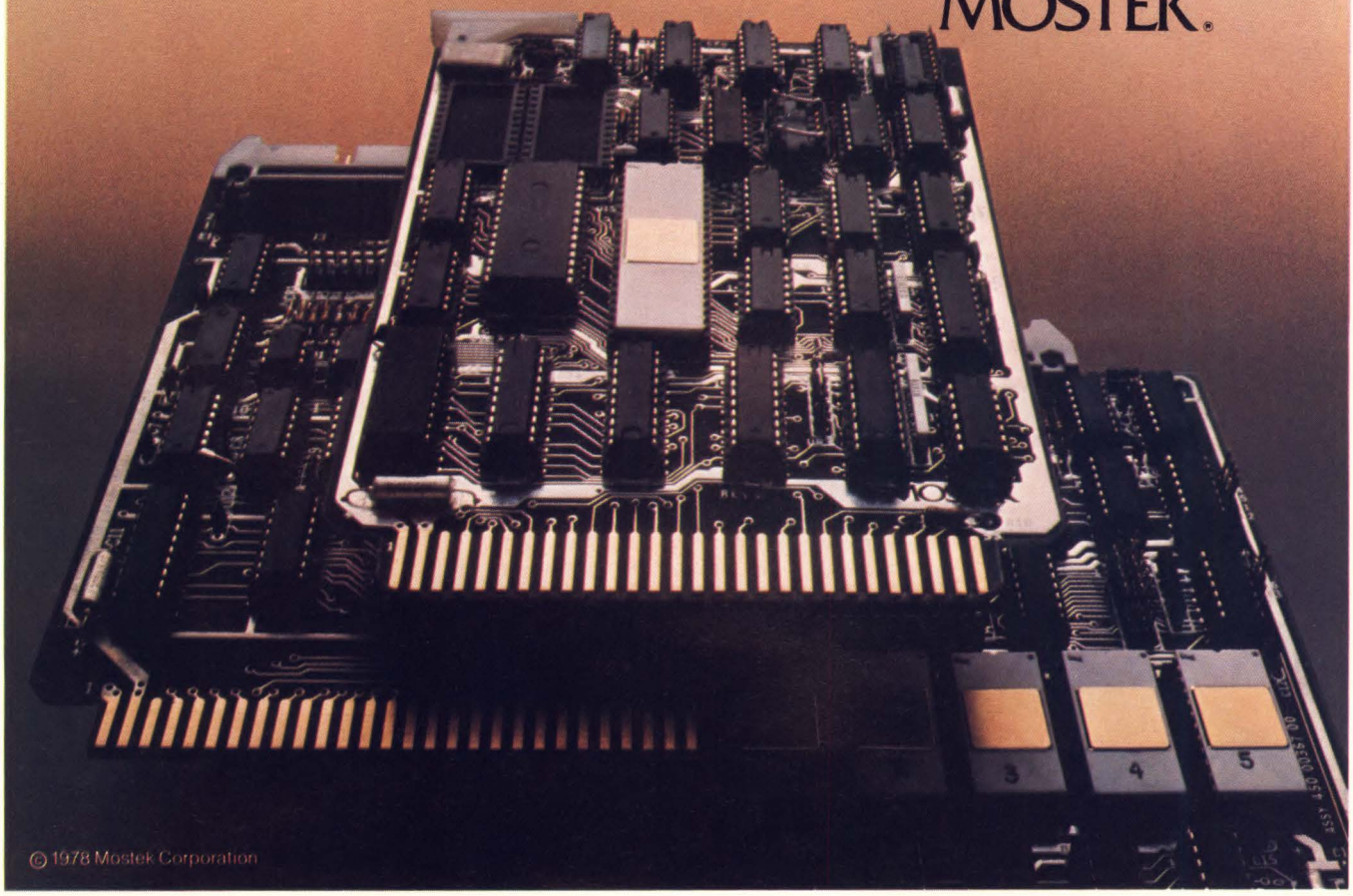

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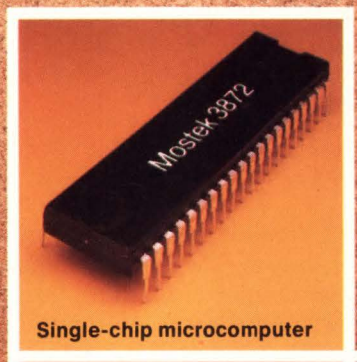
Think fast! Which microcomputer does Mostek make?



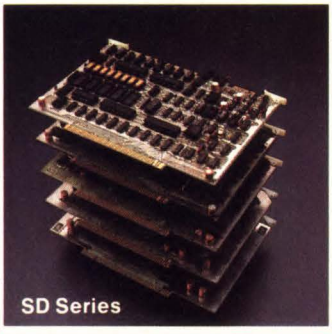
Single-chip microcomputer

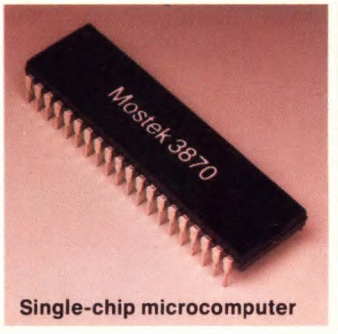
Z80 Combo Chip

3870 FAMILY

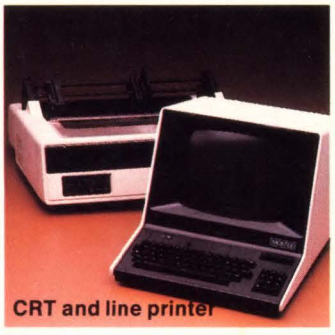
AID-80F software

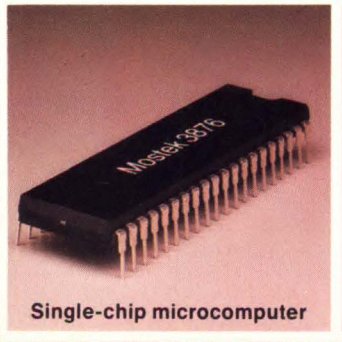
Z80


SD Series

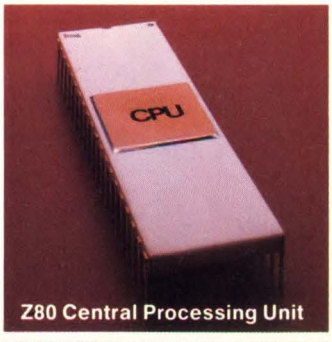


Single-chip microcomputer


CRT and line printer



Single-chip microcomputer



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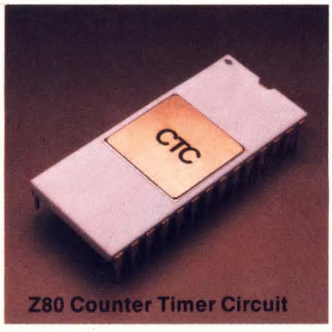
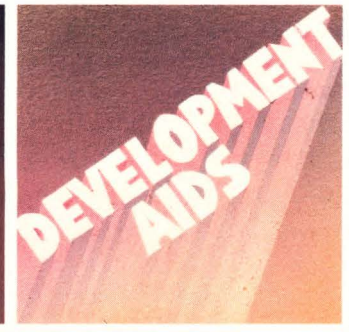
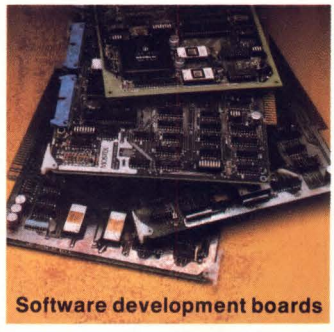
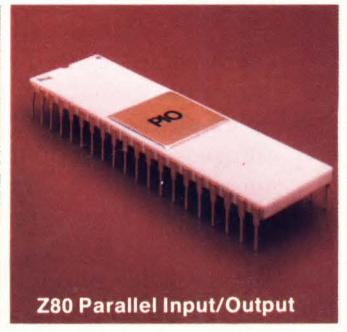


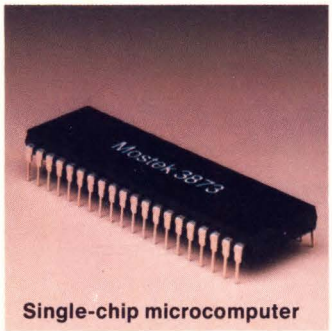
Z80 Counter Timer Circuit



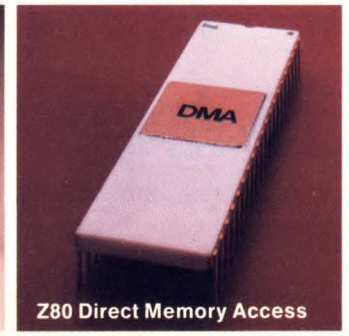

Software development boards



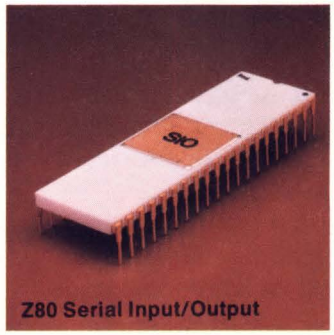
Z80 Parallel Input/Output



Single-chip microcomputer



Z80 Direct Memory Access



Z80 Serial Input/Output

Circle 83 on reader service card.

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Electronics newsletter

LS² has high speed, low power, and high noise immunity

A new family in the gathering wave of advanced high-speed, low-power Schottky logic devices for mainframe and peripheral applications is about to be launched by National Semiconductor Corp., Santa Clara, Calif. Called LS², the series features 5-ns propagation delays, 2-mW-per-gate power dissipation, and higher noise immunity than standard low-power Schottky devices. The noise immunity is increased to 800 mV maximum from 700 mV. National, which incorporated a proprietary diode network into the circuit design, says **it developed the higher noise-immunity specifications at the request of a customer that wants to cut system errors.** Earlier, Fairchild Camera and Instrument announced its FAST (for Fairchild advanced Schottky TTL) family featuring 3-ns gate delay and 4-mW power consumption. Motorola and Texas Instruments also are expected to announce their new breeds soon.

Motorola stops selling 64-K CCD memories

Mounting doubts over the cost-effectiveness of 64-K charge-coupled-device memories compared with dynamic random-access memories are causing cold feet at more than one semiconductor house these days. Intel Corp. recently backed away from the CCD market entirely, leaving announced second source National Semiconductor Corp. without a 64-K part to copy. Now comes word that another 64-K CCD second source is also precipitously close to dropping out. Indeed, Motorola Semiconductor has stopped selling its second-source part for Fairchild Camera and Instrument's F464 **because of "disappointing yields" in initial limited production runs.** An official at Motorola's Austin, Texas, plant says the company is continuing developmental production on the part but now has "significant doubts" that a cost-effective 64-K CCD can be produced. Similar concerns have also arisen at Nippon Electric Co., an announced alternate source for Texas Instruments' TMS 3064. NEC had originally planned to have samples by now, **but concerns over potential alpha-particle–induced soft error problems at the 64-K level have slowed production development.** "Now it looks as if the earliest we will have samples is the second quarter next year," says an official at NEC America's Wellesley, Mass., facility.

Wang links computer to office copier

Proponents of the electronic office of the future often discuss the advantages of **turning the ubiquitous office copier into a nonimpact computer-output printer,** and now that's just the approach Wang Laboratories is taking. The Lowell, Mass., firm has developed a microprocessor-based image printer that, combined with a cathode-ray-tube device with a dry-toner electrostatic office copier, will sell for $35,000. Fiber-optic cables transmit the CRT image to the copier in place of the paper original.

AMD to enter codec market with 2-chip, 2-channel set

Though most entrants into the burgeoning coder-decoder marketplace [*Electronics*, Sept. 14, p. 105] offer single-channel systems in either one- or two-chip form, Advanced Micro Devices Inc., Sunnyvale, Calif., plans to come out next year with a two-channel, two-chip set. The reason: **the cost-effective chip set will be the same size as current one-chip, single-channel systems.** Intended primarily for private automatic branch exchanges and central offices instead of transmission installations, it features a good crosstalk specification of less than 85 dB.

Electronics newsletter

FET boosts molecular-beam epitaxy process

Varian Associates, which makes molecular-beam epitaxial systems, says that its day has arrived for semiconductor production and, to prove it, has announced a high-frequency field-effect transistor made from an MBE-grown wafer. The Palo Alto, Calif., company claims that the FET, made wih gallium-arsenide Schottky barrier gates, **already equals the performance of FETs grown with traditional vapor-phase epitaxy.** Moreover, says Varian, it will have even better specifications in the near future. Featuring submicrometer gate geometry resulting from the use of electron-beam lithography, the FET has a gain of more than 12 dB at 8 GHz with a noise figure of less than 2.2 dB, plus very high transconductance and constant saturated-channel drift velocity almost to pinch-off.

AT&T recognizes competitors but vows to stay on top

American Telephone & Telegraph Co., New York, no longer sees itself "locked in a mortal struggle" with competitors, but now views U. S. telecommunications as **"a single industry encompassing all of us—telephone companies, Bell and independent interconnects and specialized carriers,"** says Charles L. Brown, who takes over as chairman next February. He signaled AT&T's policy switch in an address to a Chicago businessmen's luncheon, his first formal appearance since his selection. But Brown warned that "there is no sector of our business in which we intend to be second."

Active circuitry on chip for remote control

For the high-volume remote-controlled toy or hobby business, National Semiconductor Corp., Santa Clara, Calif., has a unique two-chip transmitter-receiver set that contains all the active circuitry on the chip. The 9-V battery-driven LM1871 transmitter chip is **a complete four-channel device featuring on-chip rf and i-f amplifiers and modulator** and operates at either 27 or 49 MHz. The channel information can be either analog, for proportional control, or digital, for on/off control. Its LM1872 four-channel receiver counterpart has two digital outputs that can drive lamps, solenoids, and motors and two analog outputs that provide proportional control signals to drive standard hobby servos. National, which will peg the price close to $1 each in high volume, makes the "comfortably sized" chips on a standard linear process.

Addenda

The National Aeronautics and Space Administration has given up on the Seasat-A satellite, the first ocean-monitoring system with microwave instruments. **An apparent short circuit caused ground control to lose communications with the bird,** which was to provide data on ocean currents, waves, and storms. . . . Varian Associates' selectable-emission-wavelength light-emitting diodes **are now available commercially on a limited basis,** says the company. . . . Hewlett-Packard Co.'s Computer Systems group is developing **a nonimpact printer to compete with impact printers turning out 500 to 1,000 lines per minute,** according to Paul C. Ely, manager of the group. The printer will fit midway between the very high-speed expensive nonimpact printers and the limited-applications low-end nonimpact types. . . . **Donald J. Yockey is the new head of Rockwell International Corp.'s $1.3 billion Electronics Operations in Dallas.** In effect, he succeeds Donald R. Beall, slated to become president of the corporation in February. Yockey previously was president of the Systems Group in Anaheim, Calif.

Motorola presents a SuperPower C106 SCR; and the lowest-cost 8 A Triac yet.

MCR 72–Twice as good with an MPU.

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Oxide-isolated C-MOS yielding n-channel speeds

Mitel Semiconductor readies fast, low-power version of 6802 microprocessor; other devices on the way

Building complementary-MOS circuits on sapphire substrates may not be the only way to make the low-power metal-oxide-semiconductor process comparable in speed and performance to n-channel MOS. Adding a couple of refinements, like polysilicon gates and interconnections and oxide isolation to that old standby, the planar bulk silicon process, could do the trick for a lot less money.

One of the first C-MOS parts to sport these refinements is a new version of Motorola Semiconductor's popular 6802 8-bit n-channel MOS microprocessor. It will be out of the oven in several weeks at Mitel Semiconductor Inc., the two-year-old subsidiary in Bromont, Que., Canada, of Mitel Corp., a supplier of telecommunications gear.

Ups speed. According to Alan Aitken, director of operations at Mitel Semi, his process, called Iso-CMOS, will yield a device with unexpectedly high speed for C-MOS: a clock rate of 5 megahertz or better that exceeds Motorola's 2 MHz. As expected from C-MOS, power dissipation of the Mitel MD46802 processor will be low, only 15 milliwatts when running at 1 MHz; Motorola's dissipates 500 mW.

What's more, the new part will be fully static, with no dynamic charge-storing elements needing frequent refreshing. Consequently, it will run at low clock speeds, even down to dc, and can be powered down to draw only 10 microamperes. It will also run off a supply of 1 to 7 volts, making it in fact the first 1-V microprocessor.

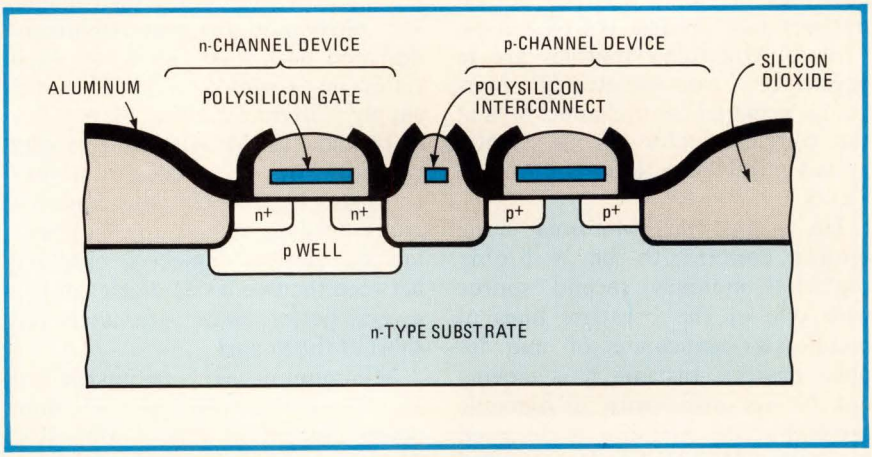
Key to the part's speed is the oxide isolation, shown in the figure. The process uses oxide to isolate p- and n-channel transistors, unlike standard C-MOS, which uses reverse-biased pn junctions. For a given operating voltage, the oxide can be made thinner than the diffusion well of standard C-MOS. Thus, the oxide-isolated parts are denser. They are also faster, because the sidewall capacitance is much less than in diffusion-isolated parts.

Also contributing to density is the self-aligning polysilicon layout process. It minimizes overlap capacitance to boost speed. The buried interconnects make tighter layouts—even though the MD46802 has more transistors. It is also smaller than Motorola's chip—185 mils on a side against 200.

Aitken says the Iso-CMOS process is now yielding "comfortably" better than 5-nanosecond gate delays at a 10-V supply for devices with channels 2 to 3 micrometers long. Also, the power-delay product of typically 0.7 picojoule per gate is much less than that of n-channel MOS. "We're getting Schottky-TTL speeds with a C-MOS power advantage," he boasts.

Mitel's 6802-type part is the first redesign of standard n-channel microprocessors into C-MOS expected next year. Motorola, for example, is working on a C-MOS 6805, a low-end microprocessor compatible with the 6800 family. And RCA Corp. will have Intel Corp.'s 8085 8-bit microprocessor in C-MOS on sapphire substrates.

"Our performance can match that of SOS, whose cost has a long way to go to match ours," declares Christopher J. Bailey, director of marketing at Mitel Semiconductor. Companies like Motorola, National Semiconductor, and American Microsystems must feel the same way. They are also working with bulk silicon pro-



Fast C-MOS. Silicon dioxide isolates p and n transistors in Iso-CMOS process developed by Mitel. Use of polysilicon gates and interconnections adds to density.

Iso-CMOS goes to master slices

Mitel Semiconductor's oxide-isolated Iso-CMOS process is also being applied to C-MOS master slices. First of the semicustom parts are likely to be available through International Microcircuits Inc., Santa Clara, Calif. "What we now have is a means for making 2,000-gate slices that have better than 5-nanosecond delays at 5 volts and are at least a third more dense than before," says IMI president Frank T. Deverse. "And that is only with a sloppy, first-pass attempt."

Until now, Deverse has been limited to 500-gate parts, with 70-nanosecond gate delays a lower limit. "We have really been confined to the customer who needs a few thousand ICs, needs them fast, and doesn't care about the speed," he says. Now he feels he will be able to reach, among other things, data-recording applications—disk drives, magnetic-tape recorders, terminals, and printers that need gate delays of under 10 ns.

"We considered low-power Schottky but found it not that good for master slice design," he continues. "We thought about C-MOS-on-sapphire but the vendors wanted $2,000 per wafer and there were some sticky interface problems to come to grips with." First parts from International Microcircuits are available now.

cesses to achieve performance akin to that of sapphire-based circuits.

Initially, Mitel's MD46802 will cost about twice as much as the Motorola part. But "we're looking to end up with just a 20% to 30% premium once we're in heavy production," Bailey says. It will also have the same pinouts and use the same software.

Mitel also wants to apply its brand of C-MOS to the market for low-power Schottky transistor-transistor logic, with telecommunications its prime target. It already offers an octal bus transceiver chip, the MD245, that is pin-compatible with the TTL 74LS245. Early next year, it plans a two-chip Touch-Tone decoder, now made in hybrid form. □

Memories

Rather than second source, Motorola designs its own 64-K random-access memory

He may mix his metaphors a bit, but David Ford's meaning is clear as he describes his plans for the hottest memory part around, the 64-K RAM. "All of Motorola's marbles are in one basket," says the strategic marketing manager for n-channel MOS at the Semiconductor Group's Integrated Circuit operation in Austin, Texas.

He means that Motorola is no longer content to be a highly regarded memory second source with one of the broadest lines of metal-oxide-semiconductor and bipolar devices. Instead, it is moving out on its own—with a dynamic random-access memory it designed itself, the MCM6664. It will offer samples for $130 each during the first quarter of next year.

Ford's announcement comes several months after Texas Instruments Inc. introduced the first American-designed 64-K RAM. Its TMS 4164 relies on a single +5-volt power supply [*Electronics*, Sept. 14, p. 39].

Though the MCM6664 also uses the single supply, as does transistor-transistor logic, it employs tradeoffs guaranteed to make things interesting for design engineers choosing between the two RAMs. For example, several performance parameters fall short of the TI part.

Minimum access time is specified at 150 nanoseconds, and maximum power dissipation is 250 milliwatts. That compares with 100-ns access times and 200-mW power dissipation for the TI part, which at 33,300 square mils is smaller than Motorola's 37,700 mil^2.

Offsetting features. In turn, the Motorola part has several useful features that company officials say more than offset the TI advantages. First is a unique automatic refresh available through pin 1 of the 6664's 16-pin package. Whereas TI chose a no-connect on pin 1, the Motorola part's pin refresh control function can activate on-chip row- and column-address strobes, eliminating off-chip counters and clocking of critically timed pulses.

Another key difference is Motorola's choice of a 128-cycle, 2-millisecond refresh. This approach requires 512 sense amplifiers on the chip, enough to make a complete redesign necessary for a next-generation 256-K RAM. But it does ease upgrading to the Motorola 64-K part from current 4-K and 16-K parts, which use the same 128-cycle refresh. In contrast, TI chose to halve the number of sense amplifiers to 128 and go with a 256-cycle, 4-ms approach, with an eye toward easing design requirements for the next generation of 256-K parts.

Motorola chose its "upgradability" for good reason. The market potential for the 64-K RAM is "bigger than everything else put together," Ford says.

Estimates are that 64-K chips will overtake 16-K devices in 1981 as the dominant RAM part. Some say total sales could amount to as much as 25% of a predicted $1 billion worldwide MOS memory market by the early 1980s.

More to come. Other memory makers, including Mostek, Intel, National Semiconductor, and Nippon Electric, are expected to introduce their own 64-K devices soon. Fujitsu Ltd. of Japan is already on the market with a 64-K part, but it needs +7- and −2-V supplies. IBM is also building 64-K RAMs for its own machines [*Electronics*, Nov. 9, p. 39].

Motorola's 64-K-by-1-bit part will be fabricated in n-channel silicon-gate technology using the company's H-MOS (high-performance MOS) process. Line geometries are 3 to 4

micrometers initially. "The idea in the beginning is to make a very producible part that we can get out in large volume," Ford explains. "We can worry about size—and cost—reductions later."

Use of folded bit-sense lines as opposed to open bit lines is also expected to cut down errors induced by alpha-particle radiation. Bit-sense lines feeding each sense amplifier are close together—only 9 μm apart. Thus, an alpha particle hit is likely to affect both lines and cancel itself out, the company says. □

Lasers

Plasma laser has tunability, power

The first steps toward a practical high-power laser tunable over a wide range of wavelengths have been taken by researchers at Columbia University in New York in collaboration with scientists at the Naval Research Laboratory in Washington, D. C. Their plasma laser, which uses light emitted by energetic free electrons in a high-temperature plasma, "fills an important gap between the spectrum's millimeter and near-infrared regions," according to Columbia professors S. Perry Schlesinger and Thomas C. Marshall of the Plasma Physics Laboratory.

The new device is more powerful than a tunable laser built last year at Stanford University in California. Also, it offers power, efficiency, and tunability never before achieved in one instrument.

Uses. Operating in this part of the spectrum, the tunable plasma laser can open up new bandwidths for communications applications, materials study, and isotope separation. Also, "there is no question about its military applications," Marshall says and adds that other groups have such uses in mind.

Although the beam can hardly be called the precursor of a death ray, it is currently capable of 1-megawatt peak power. Typical lasing materials—solid-state, gases, chemical dyes—cannot approach this power, nor are they so tunable. The laser is fired by a 1.5-kilojoule capacitor bank.

Likely in the next few years are microsecond pulsewidths that correspond to kilowatts or more of average power. Even tens of kilowatts might be possible within five years, depending on how much money is put into it," Marshall says.

With no application for the experimental system, the generated power is now being dumped against a wall. However, Marshall says it should be possible to recycle the energy in a useful application with 80% to 90% efficiency.

One potential application for the device is in materials study, where it can be used to learn about fundamental chemical and physical properties. It would be used as a tunable probe to examine the interaction of its energy at various frequencies with the material under study.

Perhaps a more direct use would be as the basis for a submillimeter-radar transmitter. Such a device could not only generate high power but would take advantage of the readily available broad tunability. For example, an easily obtained 10% tuning range would make an impressive frequency-agile radar for military countermeasures.

"The device can tune from 1 to 2 mm up to, in principle, on the order of 1 micrometer, although the technology would have to be pushed," Marshall says. (One millimeter is equivalent to 300 gigahertz). The electronic tuning adjusts the oscillation frequency of the beam itself, and a 10% tuning range requires only a 5% change in beam energy.

Further work is necessary to make the prototype suitable for specific applications. Pieces of other technologies, like aiming, focusing, and tracking, must be blended in. Such a task is for a facility more oriented toward systems applications than is the Plasma Physics laboratory. □

Why a plasma laser?

The plasma laser is a new development using free electrons that are not bound to any atom or molecule. These energetic particles, moving at almost the speed of light, have no energy constraints and can be made to emit photons, or bundles of light energy, at almost any frequency in the spectrum.

In conventional lasers, the electrons in the lasing material are bound inside atoms and molecules. Therefore, they can produce only one or, at most, several discrete oscillation wavelengths. Thus the basic physics of the device limits it's tunability to a narrow band. The free electrons, on the other hand, have no such energy limits, hence the wide tunability.

For the plasma laser, electrons are injected into the structure by an accelerator pulsed by a capacitive-discharge machine. As they pass through specially shaped magnetic fields, they oscillate in unison. Precise control over this oscillation is what gives the new laser its power, bandwidth, and wide tuning range.

Computers

Wang sets up shop at new stand

Ben C. Wang widened eyes when he parlayed Wangco, a memory-drive and controller firm he founded in 1969, into a $30 million-plus, 1976 acquisition by Perkin Elmer Corp. Now he has formed Rexon Business Machines Inc. in Los Angeles to aim at a different target: the fast growing market for small computers needed by businesses.

His first product, a multiple-terminal system, will be out in May, Wang says. Helping to bring it along is $2 million in privately raised capital; Peter F. Zinsli, a founder in 1968 of Computer Machinery Corp., another glamour grower in peripherals; and Russell C. Gerns, an early officer at that company.

Wang is convinced he must move

quickly. "The timing's got to be now," he says. "In two years it'll be too late." By then, capital requirements, technology needs, and fierce competition will close down opportunity, he believes.

Differences. "We're staying away from the single terminal computer," says Wang, who sees the big demand for two or more stations. Accordingly, the Rexon MTS system, past the design stage, "is composed of a central processing station which accommodates multiple processors, memory and bulk storage, and interfaces to eight or more terminals and printers," Wang says.

For a central processor, the Rexon unit uses Intel Corp.'s 16-bit 8086 microprocessor. Wang points out that it permits a floating decimal feature he deems critical for business machines and can address up to a million bytes.

Rexon's basic system has the central processing station and two terminals with cathode-ray-tube display and keyboard. Two cards, one for processing and one for input-output, handle up to four terminals. With the 8086 on the processor card are 64 kilobytes of random-access memory for the operating system, as well as support electronics.

The I/O card holds two flexible-disk controllers, four serial I/O channels for interfacing operator terminals at speeds up to 19,200 bauds, and an interface for a parallel printer. Software language is Basic.

Price of a two-station Rexon system will be about $25,000. By adding cards, it can be expanded to a $40,000 eight-terminal setup. At these prices, the system will come in under such competitors as IBM's System/34, Burroughs' B80, Sperry Univac's BC/7, and other multiterminal small-business systems. It is almost as cheap per terminal as the smaller, stand-alone desktop business computers such as the IBM 5110 and Wang Laboratories (no relation) equipment selling at around $15,000.

Wang is close-mouthed about how Rexon will handle sales. "All I can say now is it will be different than anybody has done it so far." He rules out retail computer stores, distributors, and franchised dealers, which could leave direct sales.

The schedule calls for moving into a new plant next February and turning out about 100 systems for the year. Wang expects break-even operations by the end of 1980 and believes that, if things go right, "a $100 million company is in the cards in five years." □

NCR announces fast mainframes

Best known for its retail and banking terminal systems, NCR Corp. is reminding the world that it competes in the general-purpose mainframe computer market as well. Late last month, the Dayton, Ohio, manufacturer announced it would bolster its line with two mainframes that weigh in against IBM's top-of-the-line 3032 and 3033 computers.

The forthcoming V-8650 and the dual-processor V-8670—to be available in late 1980—are the first mainframe computers announced to use the new 64-K random-access memories. Moreover, they will rely on the minicomputer style of bus architecture that NCR introduced about a year ago in its 8500 Criterion line of mainframes and on the very fastest emitter-coupled logic.

Mainframe speed. Although the 64-K parts are slower than current 16-K dynamic and 4-K static parts used in mainframes, NCR says it can still meet the speed requirements of a mainframe memory. It will do this partly by means of memory interleaving to permit four simultaneous accesses to fetch a total of 16 bytes per cycle and partly through the way it organizes the chips.

"And we'll couple the memory with a bipolar cache memory with a 28-nanosecond cycle time that will reduce the data-fetch time by a factor of six," says Tom Tang, who is the firm's chief engineer for the computers. The cache memory is a first for an NCR mainframe.

Tang says he wants parts with a read access time of 120 ns and a full cycle time of 250 ns. With these, he will build a memory system with a cycle time of 380 ns.

The 64-K parts will also cut memory prices dramatically: NCR will charge $49,200 per megabyte. IBM charges $18,000 per megabyte for the 64-K memory in its new 8100 system but still charges $110,000 per megabyte for mainframe memory.

For its microprogrammed central processor in the two computers, called the 8600, NCR will rely on 100K ECL with 750-picosecond gate speeds from Fairchild, Signetics, and others. With pipelined architecture and a cycle time of 28 ns, it will be about twice as fast as IBM's fastest.

The internal transfer bus in both computers will be 32 bits wide and operate at 18 megahertz, moving

Powerful. Top-of-the-line V-8600 central processor, most powerful yet introduced by NCR, uses 64-kilobit random-access memory chips and fast emitter-coupled-logic 100K circuitry.

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data at 72 megabytes per second, says Tang. Attached to this bus will be the 8600 central processor, two medium-scale computers acting as the systems' controller, and two to four input/output channel processors, each of which will control eight channels with data transfer rates of 2 megabytes a second.

Operating system. Both units will use NCR's Virtual Resource Executive operating system that can handle either batch or transaction processing and includes telecommunications, data-base management, and interactive applications capabilities. Cobol, Fortran, and RPG programming languages will be supported.

The V-8650 will have from 4 to 8 megabytes of memory and range in price from $2.4 million to $3.5 million. The V-8670 can be expanded to 16 megabytes of memory and costs from $3.8 million to $5.3 million. A prototype 8600 is now being completed. NCR defends its early announcement, claiming the planning cycles for potential users of such a large machine are long, and this gives them ample time to evaluate the new computers. □

DEC has designs on business machine

How is this for unusual marketing? "We're approaching the cabinets of our computers as empty canvases and have contracted an artist to fill those empty canvases with color."

So says Julius Marcus, vice president of Digital Equipment Corp.'s Commercial Products group in Merrimack, N. H. Rather than offer machines in traditional, but pleasant, pastel shades, DEC is introducing a small business computer decorated with the abstract designs of Corita Kent, a Boston graphic artist and printmaker. The designs, to be copied from six original serigraphs commissioned by the company, are going on the company's Datasystem 150, the newest and smallest member of its Datasystem line of small business computers.

Art. Abstract designs on side panel and on wall are part of DEC's approach to selling its Datasystem 150 small business computer.

The 150 consists of three PDT-11 intelligent terminals combined with DEC's CTS-300 commercial operating system software. The unit can function as an intelligent station in a network or as a stand-alone computer processing items like payrolls, accounts payable and receivable, general ledgers, and inventory.

Prices. The smallest Datasystem 150 consists of an LSI-11 processor, 32 kilobytes of main memory, 512 kilobytes in a dual flexible-disk storage unit, plus a cathode-ray-tube terminal. It will sell for $7,900 when deliveries begin in March. The serigraph designs are optional. Two 30-by-30-inch end panels for the work station, plus a related wall hanging, are $125; a pair of somewhat larger end panels for the central processor sells for $95.

Says Patricia Colbert, a market development specialist at DEC: "The secretaries or clerks using these systems are becoming major buying influences. We want to do something to make them feel comfortable in their surroundings." □

Mostek programs 3870 for data nets

The demand for remote intelligence in distributed-processing networks is expected to open new markets for single-chip microcomputers next year. So Mostek Corp. aims at staking a major claim in that field for its MK 3870 family of 8-bit parts.

The Carrollton, Texas, firm plans to have samples in the first quarter of 1979 of a new programmed version of the 3870 adapted especially for remote networks in industrial-control and alarm/security applications. The idea is to program the 3870's 2,048 bytes of on-board read-only memory with commonly needed functions, which can then be commanded by a master controller through a simple, serial communications channel.

The company thus hopes to make a general-purpose device that designers can simply drop into place at each network location. They will not have to write software or design discrete logic.

Interaction. The programmed 3870, which Mostek calls a serial control unit (SCU), is designed to operate in a multidrop, half-duplex, polled environment. It will interact with a central controller over a twisted-pair line using a new serial communication protocol the company has developed also.

Rather than transfer large amounts of data, as factory management systems often do, Mostek envisions control-oriented systems. Data passed asynchronously over the SCU network lines will be limited primarily to short command messages from the central controller, together with some polled feedback data from the remote stations where the SCUs may be performing functions such as surveillance or temperature control and monitoring. At the same time, the central controller, which could be anything from a standard 3870 or Zilog Z80 to a minicomputer or a mainframe, will be free to perform

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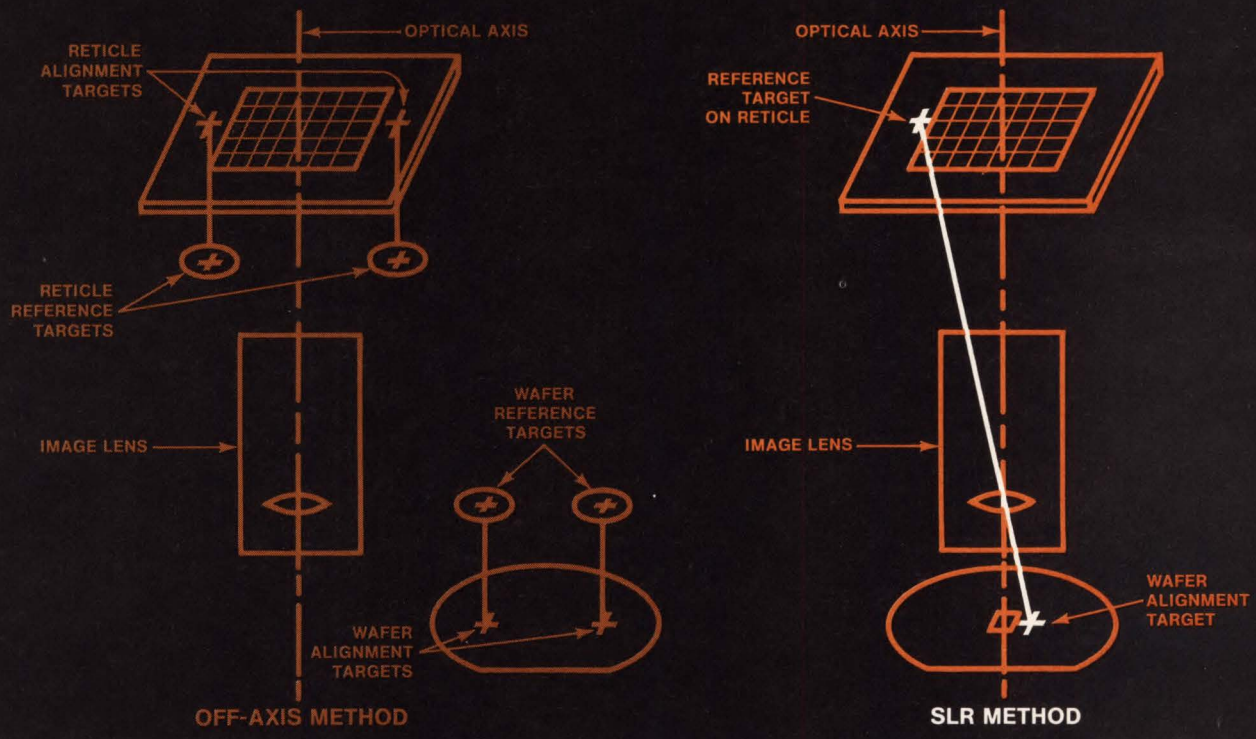

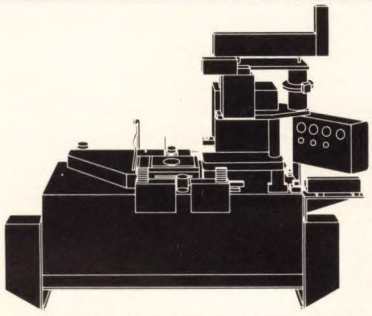

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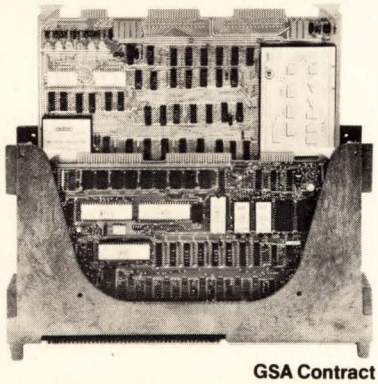

GSA Contract Group 66

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Mostek turns to new memories, too

Mostek wants to make a new mark in more than microprocessors next year. It will get aggressive in memories as well. According to Gordon Hoffman, manager of the Computer Products group, Mostek will introduce memories intended for everything from low-end consumer uses to the high-reliability and high-speed applications conventionally served by bipolar devices.

Altogether, 14 new memories will emerge from the company during the next 16 months. Many will be built with Mostek's new Scaled Poly 5 process, which uses step-and-repeat photolithography to reduce line widths to 2 to 2.5 micrometers. The parts rely on a single 5-volt supply.

Hoffman is also reorganizing his group into four departments, each with profit-and-loss responsibility. One will handle Mostek's bread-and-butter random-access-memory business, which includes its industry-standard 4027 4-kilobyte and 4116 16-kilobyte RAMs; another deals with static RAMs, read-only memories and programmable ROMs. The third department looks after memory systems that will include IBM add-ons, and the fourth will apply memories to military products.

Static RAM. Available in small quantities this month is the MK 4801, a 1-K-by-8-bit static RAM, essentially a scaled-down version of the MK 4118 introduced last summer. Access time of the 4801 drops to the 50-to-90-nanosecond range, from the older device's 120 to 200 ns. It will be aimed at small, high-speed cache memories and for use with bipolar microprocessors. A 64-K RAM is also expected soon. And a scaled-down version of Mostek's MK 36000 64-K ROM has produced typical 35-to-40-ns access times.

"Mostek has historically been highly dependent on a couple of dynamic RAMs," Hoffman observes. But during the coming year, he promises, "we're going to expand our number of memory products dramatically and widen our leadership role frm just dynamics into the static and wide-word memory areas as well." Last year, Mostek had $85.6 million in sales, 78% from memories as components.

other programs and functions.

Price of the SCUs will be about 20% more than the standard 3870, which sells for $9.50 each in 1,000-piece quantities. An SCU network should be 30% to 60% cheaper than a comparable control network with a universal asynchronous receiver/transmitter, line drivers, and discrete logic components at each remote location, says Bob Schweitzer, microcomputer marketing manager at Mostek. "We can displace a hell of a lot of discrete logic with this thing."

Serial protocol. The new protocol consists of a series of 8-bit data messages addressing the SCU and then polling or commanding its various functions. Error detection is accomplished by transmitting a complete data complement following each message. This approach does sacrifice some data throughput, but it should provide a high degree of error detection without requiring a separate hardware circuit or a complex, time-consuming software algorithm, says Mostek applications engineer Robert Burckle.

As many as 127 SCUs can be accommodated on each network line, he says. With a 9,600-bit-per-second data rate, a communications sequence in which the master controller polls an SCU and receives a response back could take 18.33 milliseconds. When a network contains the maximum 127 SCUs and each must be polled regularly, response time may be slow. But Burckle points out that the controller could be adjusted to poll high-priority SCUs more frequently where quick alarm or response time is necessary.

Mostek's success in selling the new units in volume may depend upon the functions programmed. The posiblities are numerous. One user might want the SCU to hold functions for analog-to-digital data conversion and motor-stepper control, for example. Another might want to drive a binary-coded-deci-

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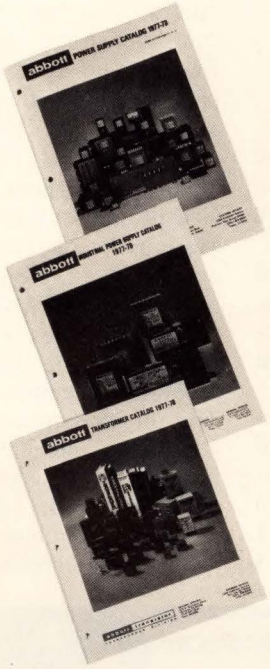

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News briefs

Fenton is new AEA chairman

Noel J. Fenton, president of Acurex Corp., Mountain View, Calif., is the new chairman for 1979 of the American Electronics Association, formerly WEMA, the nation's largest electronics trade association. Fenton, who had been on the board of directors and the executive committee of the association, headquartered in Palo Alto, Calif., succeeds interim chairman Edwin V. W. Zschau, chairman of System Industries Inc., Sunnyvale, Calif., who for business reasons declined to be considered for a full term. Fenton, who joined Acurex in 1966 as Products Division general manager, is also that company's chief executive officer. He has a BS from Cornell University and an MBA from Stanford University's Graduate School of Business.

mal display, read badges and count external events. "We can probably get 10 to 15 functions in there pretty easily," Burckle says. Mostek designers are attempting to choose among the possibilities. And if the SCU is successful, Mostek plans later to offer the programmed option on its MK 3873, a device equipped with a serial input/output port. □

Consumer

Language translator relies on plug-ins

The question keyed in by the marketing vice president was an urgent one: WHERE IS THE BATHROOM. The electronic translator he held in his hand was not fazed in the least as it converted the English into Spanish. DONDE ESTA EL BANO soon appeared across its red light-emitting-diode display.

Thus began the public introduction last month of a new kind of device—a language conversion computer made possible by advances in microelectronics. The translator [*Electronics*, Nov. 23, p. 34] was developed by Lexicon Corp., described by its marketing chief, Christopher Washburn, as "a tiny, tiny, small company" in Miami.

Lexicon was organized five years ago by a Greek immigrant, Anastasios Kyriakides, with the idea of developing an electronic device for translating one language into another. But it was only this year that the translator could be made to sell for what Washburn regards as an attractive price—$225, which includes one plug-in module that translates back and forth between English and another language. Capabilities other than translating are also distinct possibilities.

What makes the unit, the LK 3000, feasible now, says engineering vice president Michael Levy, is the availability of two integrated circuits: the single-chip 3870 8-bit microcomputer from Mostek Corp., Carrollton, Texas (see p. 46 for related story), and a 64-kilobyte read-only memory, also Mostek's. The microcomputer interprets what is punched into a 33-key dual-function keyboard, controls the characters displayed, and searches for words stored in memory.

The ROM stores some 1,500 words

Interface. Hand-held language translator measures a little over 6 in. wide and 3.75 in. high. The languages it translates and functions it performs can be tailored with modules plugged into a slot in its underside. The unit requires 0.5 watt from 500-milliampere-hour nickel-cadmium batteries.

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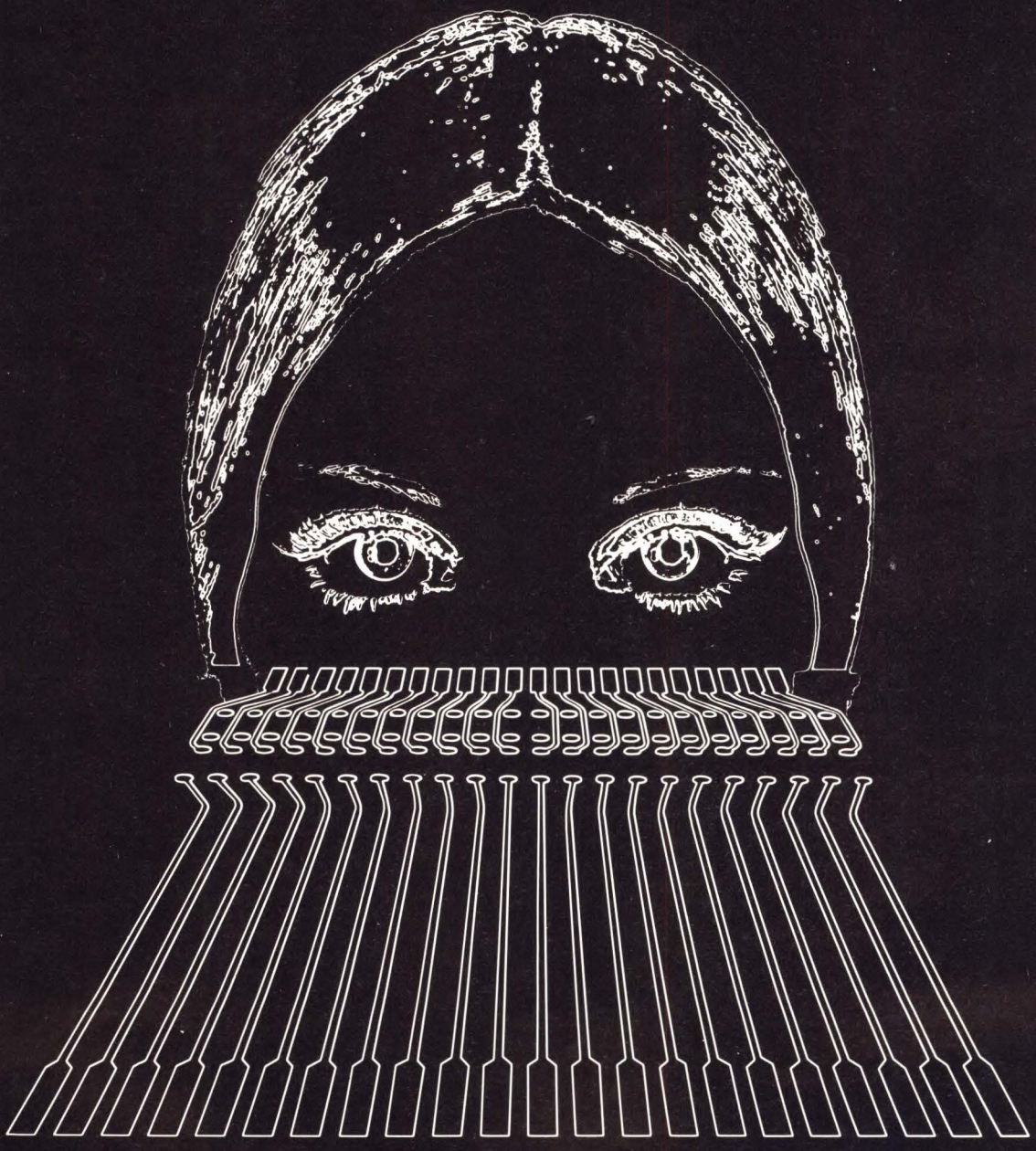

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Electronics review

and phrases in each language for everyday use. It is part of the 3-by-2¼-inch language module.

Right now, Lexicon has programmed modules (at $65 each) that will translate English into Spanish, French, Italian, German, Portuguese, and vice versa. By next June, it will have modules for 13 languages, including Hebrew, Japanese, Chinese, and Russian.

Flexibility. Despite the extra expense, Lexicon includes the microcomputer in each module, instead of housing it in the keyboard unit, because of the flexibility this gives, says Levy. "We can do anything possible with a keyboard simply by plugging in a new module," he explains. "The keyboard and display are strictly an interface—an input/output device. When memory chips go to 256-K and up, and microprocessors get even better, we can apply them simply by including them in a plug-in."

Accordingly, Levy says that Lexicon will be coming out with new applications, including a plug-in module for a calculator. Speech response is also a possibility. He declines to be specific about what else is planned.

He points out that Lexicon relies on a special data-reduction algorithm for storing the program and word combinations. "We would need twice the memory capacity if it were stored in ASCII code," he says.

Also new is the LED display—a 16-segment starburst design that includes memory decoder and driver in a fully encapsulated package from Litronix Inc., Cupertino, Calif. The LEDs, to go to distributors by the end of January, come in four-digit modules and are cheaper than, for example, five-by-seven-dot matrix units. Each digit measures 0.69 in. wide, 0.79 in. high and 0.22 in. thick. At less than $15 in 1,000-and-up quantities, it is the most expensive part of the unit.

How is the LK 3000 doing? Washburn says he has orders so far worth $3.6 million, and that he could probably sell 250,000 units through the end of next year. Not bad for a tiny, tiny, small company. □

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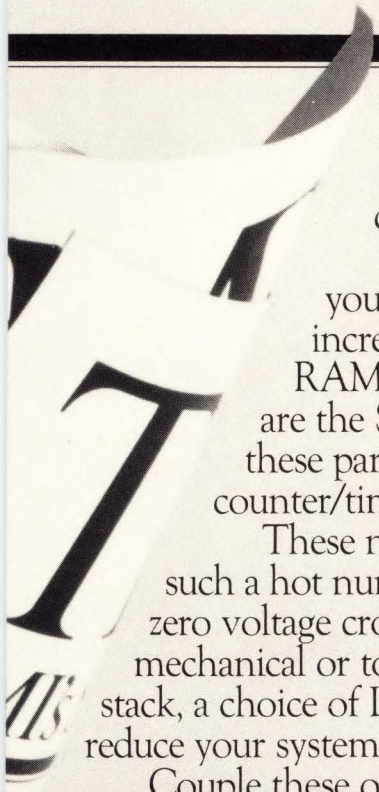

Our first 4-bit computer-on-a-chip was a smash hit. Designers found the S2000 ideal for all kinds of appliances, process and industrial controls and automotive applications.

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These new wrinkles are in addition to all those features that make the S2000 such a hot number. The powerful set of computer instructions, direct SCR or triac drive, zero voltage crossover detection, 4.5 microsecond execution cycle, inputs for mechanical or touch switching, 50/60 Hz power monitor option, three-level subroutine stack, a choice of LED or fluorescent display drive and much, much more, all designed to reduce your systems cost.

Couple these outstanding features with AMI's advanced floppy-disc based CRT development system, logic analyzer and circuit emulator and you've got the answer to your design problems. In fact, there's so much going for us that we decided to compare the S2000 with all the major low-end microcomputers. The results may surprise you.

OUR WALL CHART WILL SET YOU STRAIGHT.

We've put together a detailed chart comparing offerings from AMI, Motorola, National, Texas Instruments, Mostek, Intel and Rockwell.

It covers specs on each low-end circuit in more than two dozen different categories. All the significant features are included. (We didn't have to skip any to make ours look better.)

Obviously, we wouldn't have published these findings if they didn't show clearly that the S2000 family rises head and shoulders above the others.

But don't take our word for it. Send us the coupon and we'll send you a copy of our comparison chart. (It's printed as a handsome poster.) Or call us at (408) 246-0330. Pretty soon, you'll be designing some new products that run rings round your competition.

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The R-61 and R-80 are a great team. Convenience, economy, flexibility and top performance make data recording better than ever before.

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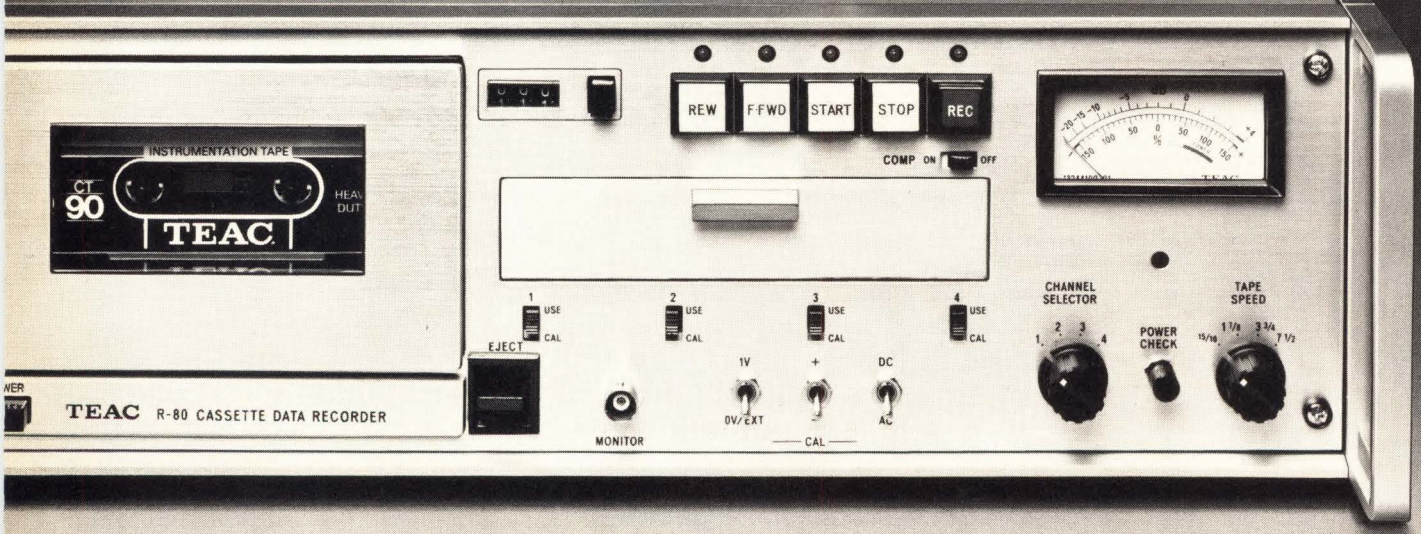
R-61



R-80

TEAC CORPORATION: 3-7-3, Naka-cho, Musashino, Tokyo Japan.

U.S.A.: B.J. Wolfe Enterprises Inc., 10760 Burbank Blvd. North Hollywood, Calif. 91610 **England:** International Instruments Ltd., Cross Lances Rd., Hounslow, Middx **W. Germany:** nbn Elektronik Starnberg, 813 Starnberg, Max-Emanuel-Str. 8 **France:** Tekelec Airtronic S.A., Cite des Bruyeres, Rue Carle-Vernet 92 Serves **Holland:** SIMAC Electronics, Veenstraat 20, Veldhoven **Italy:** A.E.S.S.E. S.R.L., Cors Lodi, 47 20139 Milano **Norway:** Rodland & Rellsmo A.S., Gladengveien 3A, Oslo 6 **Sweden:** Teleinstrument ab, Maltesholmsvagen 138, Vallingby **Denmark:** Danbit, Plantagevej 23, 2680 Scolrod Strand **Switzerland:** Wenger Datentechnik, Bruderholzstrasse 45, 4053 Basel **Australia:** Jacoby, Mitchell Ltd., P.O. Box 70, Kingsgrove, N.S.W. 2208

Circle 56 on reader service card

Washington newsletter

States may doom electronic checkout, OTA study says

The market for electronic checkout systems for supermarkets and other retail outlets may die aborning because state laws require prices to continue to be marked on individual items. That is the judgment of a new study for Congress by its Office of Technology Assessment, which says the legislation, on the books in 30 states, makes the future of electronic checkouts "uncertain at best." **Retailers would no longer have the incentive of reduced labor costs that electronic checkout systems offer by eliminating item price-marking.** The OTA says about 300 supermarkets now use the systems, which cost approximately $200,000 each.

Antitrust threat seen killing merger of GE, Hitachi TV

Expressing disappointment, Hitachi Ltd. says it still has to analyze the U. S. Justice Department's threatened antitrust action against the proposed Hitachi-General Electric Co. television merger before deciding on any action. But the threat seems to have killed the plan for a joint venture to be called General Television of America Inc. [*Electronics*, Dec. 22, 1977, p. 34].

The joint venture "would eliminate significant existing and potential competition between GE and Hitachi in both color and monochrome TV sets," says John Shenefield, assistant attorney general in charge of antitrust. The combination of GE, ranked 5th in U. S. sales, and 12th-ranked Hitachi **would make the new venture the country's third largest color producer and fourth largest monochrome maker,** creating unacceptable concentration "in the already concentrated market," Shenefield says. Industry lawyers in Washington believe Hitachi has no choice but to pull out since, as one put it, "it would only be buying litigation if it proceeds."

GSA consolidates buying power for data communications

The General Services Administration expects to eliminate confusion over telecommunications and data-processing equipment and services and make life simpler for contractors bidding for those contracts. Administrator Jay Solomon has expanded the procurement authority of GSA's Automated Data and Telecommunications Service to include telecommunications equipment and services. It already is responsible for buying all Federal data-processing hardware, software, and services. Telecommunications purchases were formerly handled by GSA's Federal Supply Service. **Solomon says the change should eliminate problems with classification of products** like terminals, modems, and data sets that can perform both data-processing and telecommunications functions.

GE proposes low-power microwave system at 22–23.6 GHz

General Electric Co. wants the Federal Communications Commission to approve its use of the 22-to-23.6-GHz band for a new "short-haul, low-power, low-cost microwave system" designed by the company's Microwave and Imaging Device Products section, Lynchburg, Va. The FCC has requested comments by Dec. 17 on the GE proposal to use the frequencies that it says have otherwise limited value. **The company says its system has widespread potential for use in systems for traffic control, closed-circuit TV security and surveillance, energy consumption and monitoring control,** as well as "other applications where voice, digital or video signals must be transmitted short distances, without interference, and in an economical manner." Since the petition calls for an FCC policy ruling on use of the frequencies, rather than type approval of specific equipment, the company did not spell out hardware specifications.

Washington commentary

Electronic mail: the Postmaster General forces the issue

For years the White House, the Congress, and the Federal Communications Commission have done nothing but mutter about the concept of electronic mail. Finally Postmaster General William Bolger is forcing the issue. In late November he disclosed that, in the absence of any Federal policy on who may develop the market and how, the U. S. Postal Service will move into the vacuum next year by running a $4 million year-long laboratory test for the digital transmission, receipt, and high-speed printout of letters for overnight delivery.

That proposal is seen as bad news by developers of private data-communications systems and services, who believe the market should be left to competitive private development. Yet the Postmaster General probably deserves their congratulations. For the good news is that Bolger's first step toward implementing a $2 billion, nationwide Electronic Message Service system over the next decade is producing a small crisis in the capital that demands a fast Federal response, specifically a policy.

No more blissful ignorance

"No one can ignore the issue any longer," says one electronic mail specialist on Capitol Hill. "Complaints are pouring in to the committees. There is a storm building and everyone is going to get wet—the White House, the Congress, the Federal Communications Commission, and a lot of others."

The Postal Rate Commission must be included in that last category. It received a brief from the Computer and Communications Industry Association opposing Bolger's grand scheme on the day of its disclosure. The CCIA has long held that the entry of the postal service into the electronic message service market would make postal monopoly an accomplished fact, foreclosing all others.

Contributing to that threat, says CCIA, is the prospect that a Postal Rate Commission claim of jurisdiction over the EMS system would diminish the authority of the FCC and further confuse the issue of regulatory responsibility. The FCC is responsible for regulating all forms of electronic communications and should retain that responsibility, the CCIA argues.

Opposition to the Postmaster General's plan is also growing among a host of private-system developers—a list that includes such heavyweights as AT&T, Xerox Corp., and the Satellite Business Systems entry of IBM, Comsat General, and Aetna Life & Casualty.

What troubles these potential competitors is the Postmaster General's proposal to start an operational test program within three years if the 1979 tests succeed, gradually expanding the EMS system to 87 cities from the initial 10. Bolger's plan seems much farther along than anyone anticipated, with annual expansion increments of up to $200 million to be drawn largely from the EMS program's own revenues.

RCA's $2 million blessing

Credit for the postal service's plan belongs in large part to its most recent study contractor, RCA Corp. It recently delivered a long-awaited EMS system study to Bolger in return for $2.3 million [*Electronics*, Aug. 17, p. 57]. RCA's analysis took two years and runs to more than 5,000 pages. It labels the postal service program feasible, spelling out a variety of possible approaches.

RCA's judgment is that the cost per letter in a high-volume system would be about 10 to 11 cents—2 cents for transmission and printout plus another 8 cents for carrier delivery. By RCA's estimate, about 25 billion pieces of mail are candidates for EMS satellite transmission. That is just about a quarter of the mail expected to be moving through the U. S. system in 1980.

The need for competition

Postmaster General Bolger says he recognizes that a fundamental policy decision from the White House and Congress is needed before the USPS can go beyond next year's tests using an in-orbit satellite to relay messages from a transmitter in one room of its Rockville, Md., laboratory to a receiver and printer in another. Moreover, he says he wants that public policy issue decided in favor of the postal service so that it can learn to "live within its income."

By accelerating its EMS test program, the postal service is certain to wake up the policymakers and set them thinking again. But the Postmaster General is kidding himself if he believes that electronics technology alone can counter the human problems of mismanagement and declining productivity that plague the postal service. Those issues will never be resolved by the postal service as it is presently structured.

If the EMS system and its supporting technology are to develop successfully, they must develop in a free and open competitive market in which the USPS participation is limited to those unique services that cannot be duplicated by industry.

Ray Connolly

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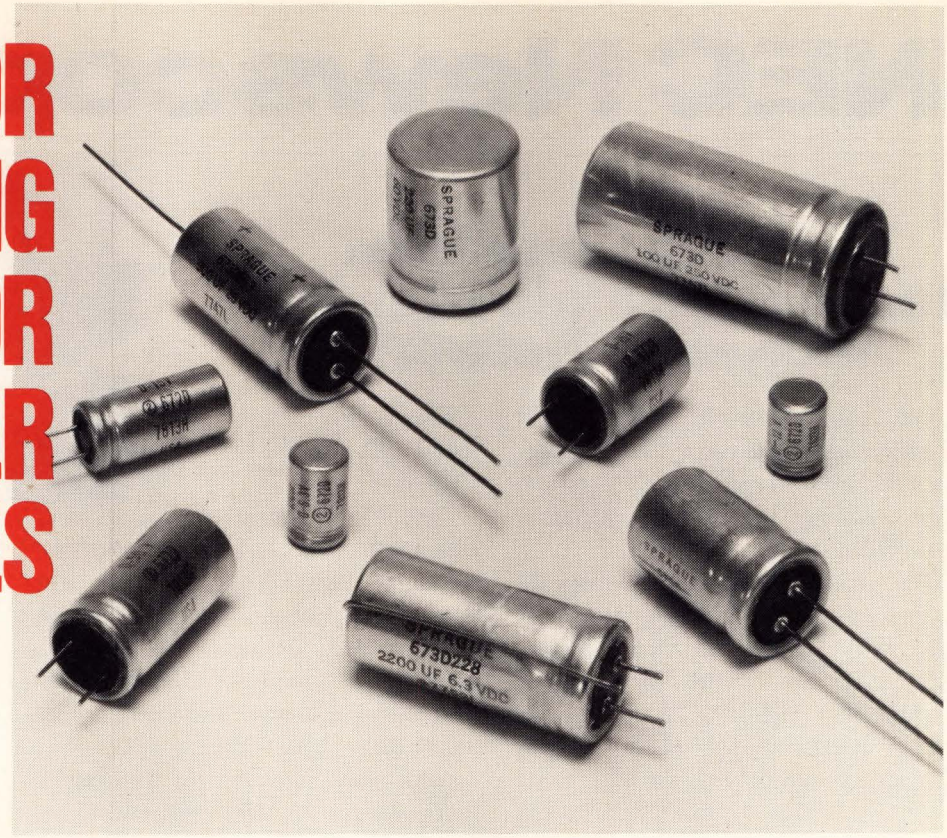

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NEC Newscope

New Link Completes Indonesian Main Islands' Microwave Network

President Suharto of Indonesia has officially inaugurated the Eastern Indonesia microwave communications system in a ceremony held at Ujungpandang, South Sulawesi.

The Eastern Indonesia microwave communications system links Denpasar, Bali, with Ujungpandang, covering a distance of about 1,100 kilometers. It provides 960 high-grade telephone circuits in 4GHz and upper 6GHz bands to offer services not only for the inhabitants of the two islands but also for the people living on the islands along the route.

The newly completed microwave system consists of 13 hops for the main route and 5 hops for spur links including 2 hops for the UHF band.

The system also includes several long hops of about 200 kilometers across the sea between Ruteng, Flores, and Ujungpandang. NEC engineers say that it is probably the first time in the world that such a long over-water distance has been linked with a line-of-sight system.

With the completion of the Eastern Indonesia system, NEC microwave systems now cover most of the country's major islands, spanning a total distance of about 4,550 kilometers.

President Suharto (left) watches as Mrs. Suharto cuts the tape at the inauguration ceremony.

NEC System Automates Brasilia's Mail Processing

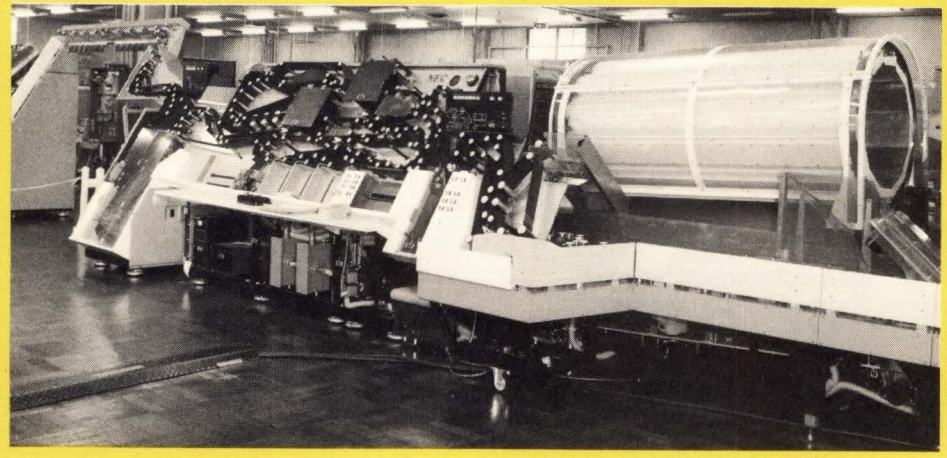
An automatic mail processing system made by NEC was officially put into service at the headquarters of the Empresa Brasileira de Correios e Telegrafos (ECT) in Brasilia, Brazil.

The system is one of eight similar systems ECT ordered from NEC last year.

The system consists of a complete line of automatic mail processing machines including a culler-facer-canceler, a postal code OCR, coding desks, OCR sorters and connectors which integrate these machines into a complete processing line. It also has a central control console.

President Geisel and those who attended the commissioning ceremony were very impressed to see the system efficiently processing 30,000 pieces of mail per hour.

Following the system installed in Brasilia, seven other systems are expected to be commissioned within a year.



Singapore's New Airport To Have NEC Radar System

The Telecommunications Authority of Singapore announced that it has awarded NEC a contract for the provision of an approach control radar (ACR) system to be installed at Singapore's new international airport now being constructed at Changi.

The ACR system will consist of primary surveillance radar and secondary surveillance radar, and will be integrated into the long range surveillance radar and display system now being implemented at the new airport site.

The ACR system will have range detection coverage from 1/3 nautical mile to 64 nautical miles for the primary radar and up to 128 nautical miles for the secondary radar, and can operate up to an altitude of 40,000 feet. It will enable air traffic controllers to guide aircraft safely to land at the Changi airport, after taking over control from the long range radar air traffic controllers.

One of the most significant features of the system is its ability to track and automatically display aircraft position with identifications using alpha-numeric symbols displayed on a large 58 cm diameter picture tube. Flight altitude and aircraft speed are also displayed.

The ACR system is scheduled for operation by September 1979 and its integration with the long range radar system two months later. With the completion of the two projects, Singapore's automated air traffic control system will be one of the most modern systems in the world.

NEC O/H System Spans Desert In New Libyan Microwave Link

An NEC-equipped high-power, multiple diversity 585-kilometer over-the-horizon (O/H) communications system is providing many great benefits for Libya, by linking Tripoli and other important cities with the country's inland oil field and agricultural center.

The 585-kilometer over-the-horizon communications link is capable of handling 120 telephone channels and one television channel. It is equipped with 20kW high-power transmitters and large 27-meter billboard antennas as well as a multiple diversity (octuple IF combining) system.

This is the second over-the-horizon system NEC completed in Libya, the first being the 320-kilometer system linking Dernah along the trunk microwave system to Lefka on the Greek island of Crete. The Dernah-Lefka link was completed in 1975 for the Posts and Telecommunications Corporation and Hellenic Telecommunications Organization Co., Ltd. of Greece.

Nation-wide Digital Data Network In Brazil By 1981

Brazil is to have a nation-wide digital data communications network, the last phase of which will be completed by the Empresa Brasileira de Telecomunicações (EMBRATEL) in 1981. NEC will manufacture and install virtually all the necessary equipment.

The network will consist of 13 transmission centers and 17 remote centers, and provide high-grade point-to-point or multi-point data communications circuits for about 4,000 subscribers throughout the country.

The transmission centers are to be inter-connected by means of 64 kb/s transmission lines which will comprise the existing long-haul FDM group band telephony circuits now being operated by EMBRATEL and 64 kb/s group band data modems to be newly installed.

In accordance with the contract, NEC will manufacture and install all the necessary equipment, except subscribers' modems and FDM circuits, to complete the network by early 1981. The equipment will include 64 kb/s group band data modems, network synchronizers, data multiplexers, main multiplexers, and PCM data access equipment.

NSV-80 Simplifies Remote Control, Monitor Systems

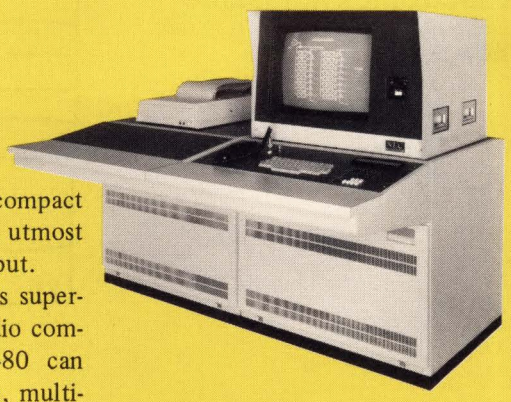
The NSV-80 supervisory and control equipment is completely new and sophisticated intelligent equipment intended for monitoring and controlling a number of remote stations centrally in a radio communications system.

The equipment can monitor up to 128 remote stations and 128 supervisory items per station.

Automatic logging by printer, graphic presentation of supervisory and control information by CRT display and other equally efficient man-machine devices give the operator a great deal of expedience and reduce the drudgery factor.

Since the equipment uses highly sophisticated NEC microprocessors throughout, it is compact and most reliable while ensuring utmost flexibility and maximum throughput.

In addition to its function as supervisory control equipment for radio communications systems, the NSV-80 can also be used as on-line, real-time, multitask data processing equipment for power plants and chemical plants and in hydro control systems, gas/oil pipeline systems, traffic control systems, building supervisory systems and numerous other applications.



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And now the same commitment to quality, reliability and technical innovation that has earned our leadership position in television, is available to you in our CRT displays. We proudly introduce the Zenith D-12 12-inch diagonal CRT display.

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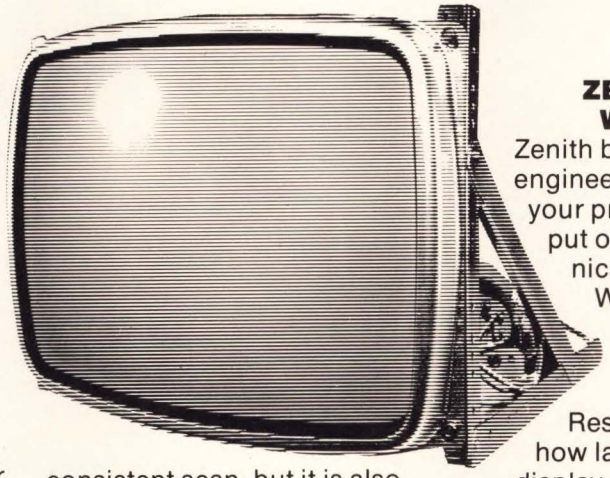

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These are just a few of the many value plusses you'll find in a Zenith CRT display.

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International newsletter

32-K E-PROM samples due from Fujitsu

Fujitsu Ltd. will start shipping samples of its MB8532 32-K ultraviolet-light-erasable programmable read-only memory in April 1979. **The device is compatible with the Intel 2732 E-PROM pinout,** not with that used by Texas Instruments and Mostek [*Electronics*, Sept. 14, p. 85]. Operating from a single 5-V supply, the device has a maximum access time of 450 ns and typical power dissipation of 450 mW.

U. S. forces to buy German gear for phone modernization

Look for the U. S. armed forces in Europe to place about $100 million worth of contracts for communications equipment with West German firms to update its European Telephone System. The ETS interconnects a number of headquarters and military bases throughout Europe, and parts of it are over 30 years old. **The Americans plan to update some 112 switching centers, probably with digital equipment.** The contracts are helping to offset the German expenditures for the Airborne Warning and Control System (Awacs) [*Electronics*, Nov. 9, p. 50].

Ferranti's ULA goes low power for new uses

Taking aim at custom complementary-MOS designs for industrial and consumer applications, Ferranti Ltd. is launching a new low-power series of its Uncommitted Logic Arrays. First in the Micropower ULA series is the ZNA 2U000, **a 256-cell array with a power dissipation at 1 MHz of 4 μW per gate and the ability to operate from supplies as low as 1 V.** Ferranti says current-mode logic cuts power consumption 96% over earlier versions. As with all members of the ULA family, the 40-pin array can combine customer-specified digital functions in its final metalization layer. Also, the interface cells associated with each pin in the new chip can be configured to perform analog functions.

Swedes finding each other with paging system

Sweden's telecommunications administration is making it easier for people to get in touch—with a nationwide automatic paging system. Using MBS (for *mobilsoekning*, Swedish for mobile searching), one subscriber can page another by dialing his or her code number from any phone in the nation. **The paging signal is processed by a central computer and broadcast over an fm radio signal.** About 10,000 of the pagers, which retail for between $500 and $890, are expected to be sold the first year. Mitsubishi Electric Corp. is the first to have a receiver type approved and will sell units to the administation for its employees' use.

Nixdorf, Brazil firm sign pact on computer know-how

Nixdorf Computer AG has signed a licensing and know-how agreement with Sao Paulo–based Labo Eletronica Ltda. The accord also calls for the delivery by the West German company of $45 million worth of computer systems and modules during the next few years. **It centers on the transfer of production, sales, and service know-how on the Nixdorf system 8870/1,** a magnetic-disk computer that has a strong position on the international market for distributed processing systems. Nixdorf says Brazil also picked Japan's Fujitsu Ltd. and France's Logabax to help establish a native computer industry.

International newsletter

BPO set to go on exchanges for packet switching

Fully committed to a packet-switching service, the British Post Office is placing orders for hardware. Within a year, **the BPO's present experimental service will give way to nine 48-kb/s exchanges** providing local traffic and access to the Euronet database-access network and to the planned IPSS, the International Packet-Switching Service. Eventually, the post office will incorporate its packet-switching exchanges into its forthcoming System X digital solid-state telecommunications exchanges.

Industrial use pointing to fiber-optic boom

With what Siemens AG claims is the first fiber-optic bus for an automated industrial-process application, the firm is connecting 28 microcomputer-controlled furnaces in a steel processing plant. **The $1 million installation is part of a fiber-optics boom in West Germany** that, says ITT subsidiary Standard Elektrik Lorenz AG, will make long-line glass-fiber systems a $15 million market by 1985. Up to 15,000 kilometers of conventional cable will be replaced with fiber by then, SEL says.

Japanese firms stepping up U. S. operations

Add two more Japanese firms to the list pushing manufacturing operations in the U. S. In about two years, **Nippon Electric Co. will be building large time-division telephone exchanges in its already-working Dallas telecommunications plant.** Next October, Sharp Manufacturing Co. of America, a subsidiary of Sharp Electronics Corp., will begin turning out microwave ovens and color TV sets in Memphis, Tenn.

Digital network will be linking Europe's railways

Due to go live in 1980 is a packet-switching network linking the freight and passenger reservation system of the railway authorities in France, West Germany, the UK, Italy, Belgium, and Switzerland. Sponsor Union Internationale des Chemins de Fer says **the net could be expanded worldwide** to serve its member railway agencies.

Addenda

More UK government money will go toward promoting industrial applications of microprocessors and microcircuit technology: **perhaps as much as $120 million, up from $30 million.** The government is taking the step in line with recommendations from its Advisory Council for Research and Development [*Electronics*, Sept. 28, p. 68]. . . . German computer maker Nixdorf says the proposed partnership with car maker VW [*Electronics*, Nov. 23, p. 70] is dead. The firm says VW wanted to play too big a role; **moreover, the giant Deutsche Bank is buying a 25% share of Nixdorf.** . . . December 6 is the date the French council of ministers is considering the **possible joint semiconductor venture of National Semiconductor and the French conglomerate Saint-Gobain.** The company would be majority-owned by Saint Gobain and subsidized by the French government. . . . AEG-Telefunken has completed **the first digital transmission leg for West Germany's integrated Telex and data network (IDN).** The 120-mile link between Hanover and Hamburg operates at 8.448 Mb/s. . . . Britain's General Electric Co. Ltd. **plans to enter the office-automation and word-processing markets** with its proposed purchase of Chicago-based A. B. Dick Co. . . . A 36% annual growth in the European market for residential fire alarms is forecast by market researchers Frost & Sullivan Inc. **By 1986, volume should be $30.2 million a year** in Sweden, West Germany, France, Britain, Belgium, and the Netherlands.

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If you're building an industrial power control or static switching system—for motors, lights, heaters, etc.—then you should look to Amperex for your TO-220 Triacs. For complete specifications and for applications assistance, contact: Amperex Electronic Corporation, Slatersville Division, Slatersville, Rhode Island 02876. Telephone: 401-762-3800.

TYPE	V_{DRM} (Volts)	$I_{T(RMS)}$ (Amperes)	I_{GT} (Milliamperes)
BT137	500	6	35
	600	6	35
BT138	500	10	35
	600	10	35
BT139	500	15	35
	600	15	35

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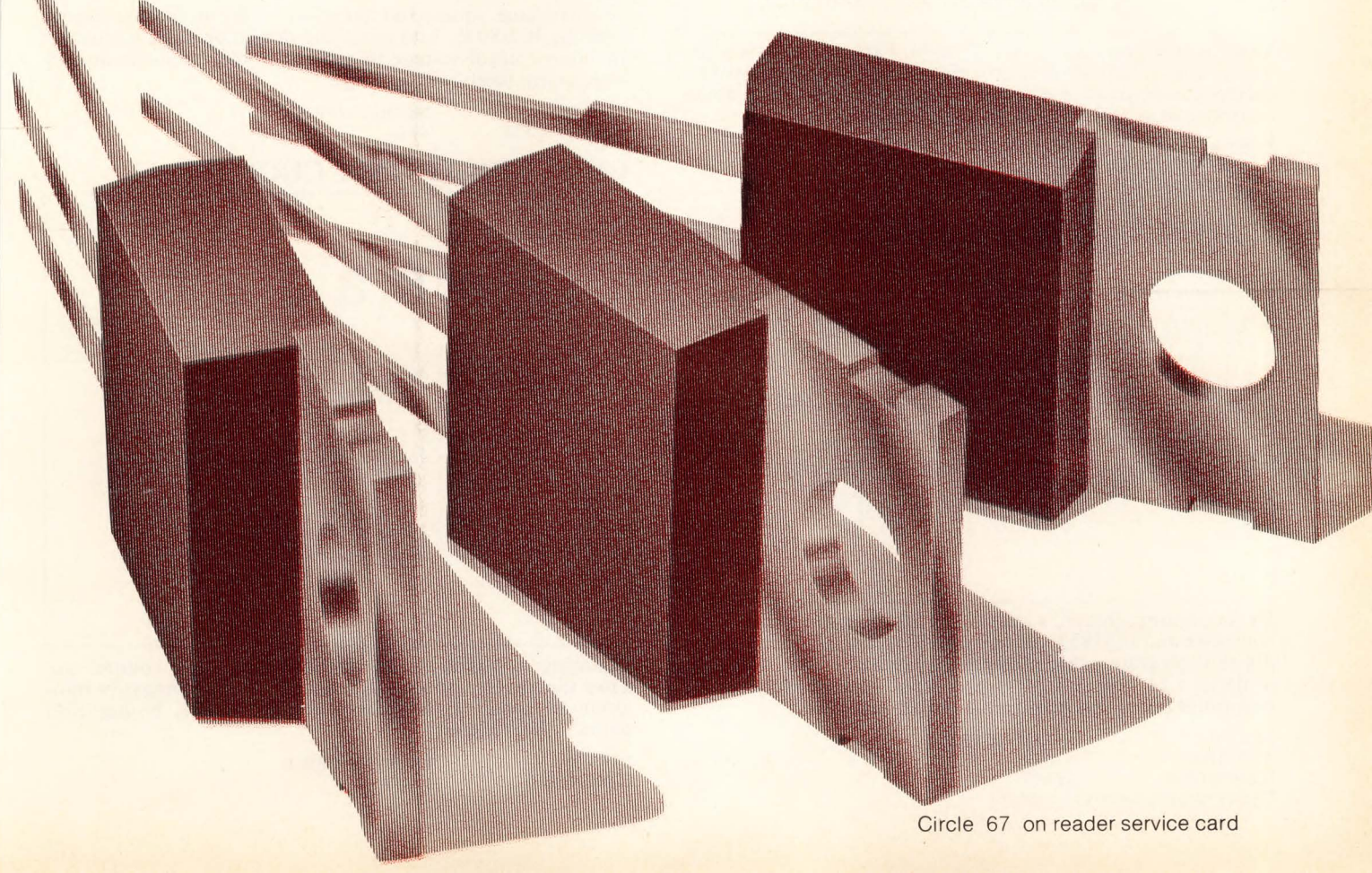

Circle 67 on reader service card

PROBLEMS AREN'T THE PROBLEM. ANSWERS ARE THE PROBLEM.

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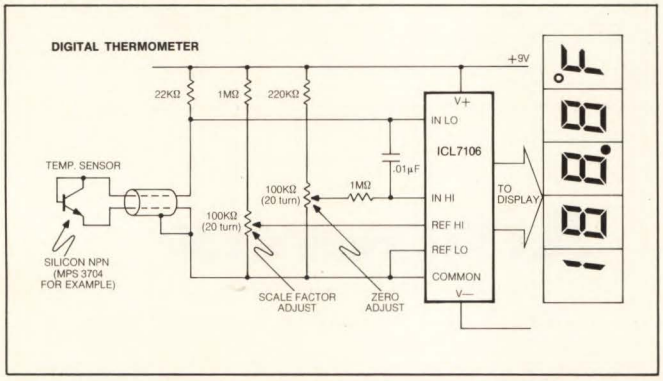
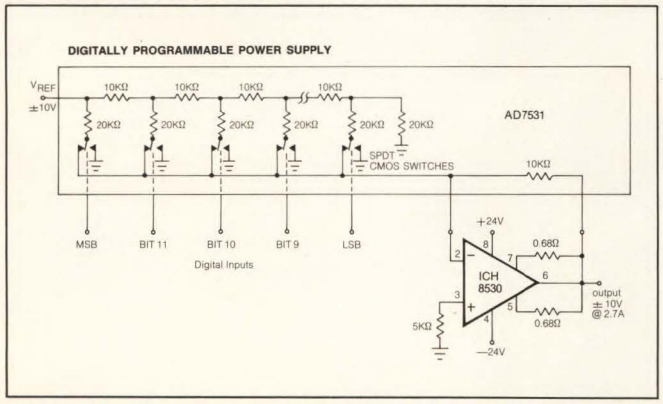
3½ DIGIT SINGLE-CHIP DIGITAL VOLTMETERS



Read temperature in either degrees Fahrenheit or Centigrade. The ICL7106/7107 3½ digit, single-chip digital voltmeters can be used to monitor voltage change across a diode sensor to drive either LCD or LED displays.

PART #	100 PIECE PRICE
ICL7106CPL (LCD)	$9.80
ICL7107CPL (LED)	$9.25

12 BIT D/A CONVERTER/POWER OP AMP

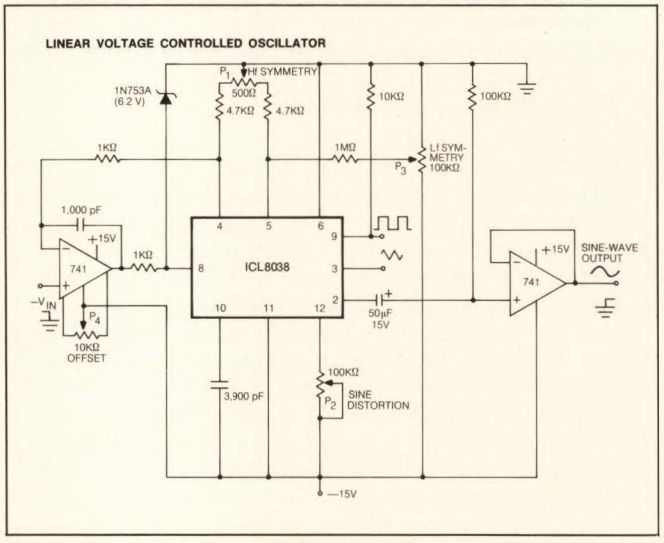


By combining Intersil's AD7531 CMOS multiplying D/A converter and ICH8530 power amplifier, you produce a 12 bit digitally programmable power supply or motor driver capable of up to ±24 Volt and 2.7 Amp output. High power output, minimum board space and total output protection.

PART #	100 PIECE PRICE
AD7531JN*	$ 8.00
ICH8530IKA	$29.95

*higher accuracy selections available

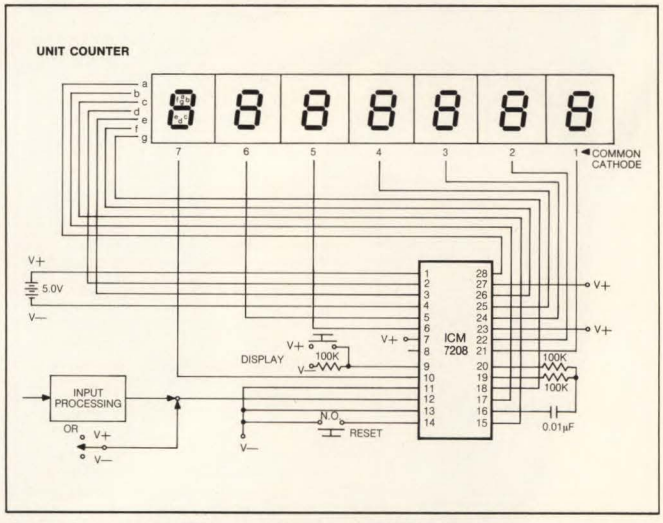
PRECISION WAVEFORM GENERATOR



Generate sine, square and triangle waveforms simultaneously with the ICL8038. Add input and output op amps to convert an input control voltage to a linear audio output frequency with nearly 1000:1 sweep range.

PART #	100 PIECE PRICE
ICL8038CCPD	$3.13

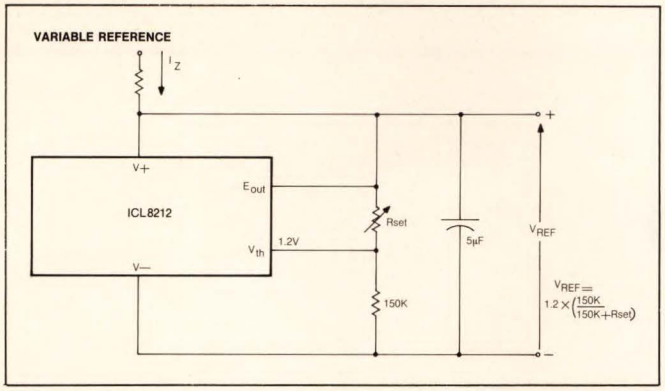
CMOS 7-DIGIT UNIT COUNTER



Counting at 5MHz speed, the ICM7208 unit counter updates the directly driven LED display for each negative transition of input signal. Count traffic, people, bottles...you name it. To 7 digits.

PART #	100 PIECE PRICE
ICM7208IPI	$10.59

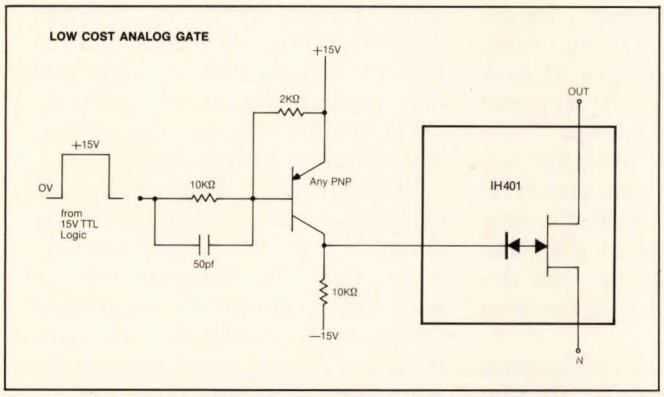
MICROPOWER VOLTAGE INDICATOR/DETECTOR/REGULATOR



The bandgap reference and gain block features of the ICL8212 voltage detector make it particularly useful as a variable voltage reference. Output voltage can be set from 2 to 30V with a lower knee current (300μA, typical) than most zener diodes. And, over a 300μA to 12mA operating range.

PART #	100 PIECE PRICE
ICL8212CPA	$1.05

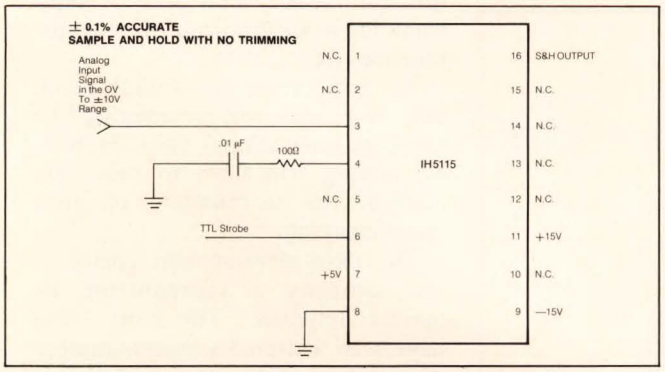
VARAFET ANALOG SWITCH



The diagram above shows just how easy it is to make your own analog gate with Intersil's new Varafet family. ON resistances are as low as 30 ohms. OFF leakages are typically in the area of 10pA. ON leakages are 20pA typical. Additionally, the Varafet family has a constant ON resistance for signals in the DC to 20MHz frequency range.

PART #	100 PIECE PRICE
IH401	$1.92

SAMPLE AND HOLD

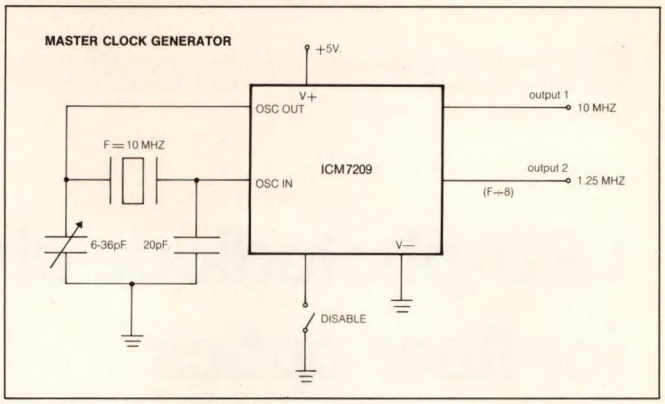


That's right. ±0.1% accuracy with no trimming required. Simply connect up the IH5115 as diagrammed above for a complete sample and hold. The built-in buffer/amplifier has a minimum input impedance of 100 megohms in the sampling mode. Strobing circuitry is completely TTL compatible.

PART #	100 PIECE PRICE
IH5115IDE*	$9.95

*Lower cost versions available

PRECISION CLOCK GENERATOR



The CMOS ICM7209 directly drives 5 TTL loads from either of 2 buffered outputs. The device is guaranteed to 10 MHz. Bipolar, MOS and CMOS compatible. Stable quartz crystal reference.

PART #	100 PIECE PRICE
ICM7209IPA	$2.40

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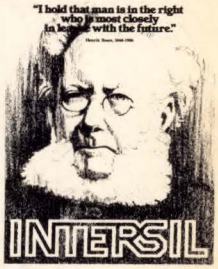

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LED-photodiode chip for fiber optics transmits and receives

Two-way communications over a single optical fiber needing no separator is the promise of dual device

The newest optical-fiber development from Thomson-CSF's research laboratories is EROS, a labor of love that has produced a gallium-aluminum-arsenide chip capable of operating either as a light-emitting diode or as an avalanche photodiode. EROS, in fact, stands for emitter-receiver for optical systems.

This single chip can handle two-way communications using one optical fiber. "Eighty per cent of communications links are bidirectional," explains Michel Triboulet, Thomson's product marketing manager for optical communications. EROS is similar in approach to the transmitter-receiver Bell Laboratories has developed for its revolutionary light-powered telephone [*Electronics*, Nov. 23, p. 39].

Till now, optical systems needed an LED for transmitting and a p-i-n photodiode for receiving. Such a circuit must have two fibers, one for sending and one for receiving, or else it needs a costly separator at each end of a single fiber. A separator also can cause insertion losses.

Compromise. What EROS has is a transmitting LED that can also operate as a receiving photodiode, says Triboulet. "The classical LED does have some light sensitivity, but this is very low compared with the p-i-n photodiode."

The new device achieves the same sensitivity as a conventional p-i-n photodiode by operating as an avalanche diode. "With the avalanche operation, the performance of the two functions is the same as with classical components," Triboulet says. However, an avalanche diode does require a higher voltage.

Thomson's Laboratoire Central de Recherches arrived at its new device by limiting the top (window) layer of the diode to 2.5 micrometers, so that it is transparent for transmitting. The diode is a GaAlAs doubled heterostructure grown on a p-type GaAs substrate. Avalanche gain is used to multiply gain 10 times and thus increase the overall sensitivity to 0.7 ampere per watt, the same as in a typical p-i-n photodiode.

More attractive. Triboulet expects to launch the device on the market in about a year. "Currently development work is concentrated on improving performance repetitivity for quantity production," he says. He hopes that EROS will enhance the attraction of Thomson's fiber line.

"Where fibers compete against twisted-pair copper wire, we are up against cost competition," he says. "But if we can offer a single optical link to perform the same functions, we look a lot better."

The 0.4-nanometer bandwidth can cope with data rates up to 30 megabits per second. This will be sufficient for a medium-rate data-transmission system, he says.

No firm prices are available yet, but chip costs will be roughly the same as conventional LEDs. However, pricing will have to take into account the surrounding circuitry and packaging.

The EROS development comes as the company is reorganizing its optical activities. Till now, these have been scattered among a number of operating and research divisions and companies in the Thomson group. Overall coordination responsibility will be handed to Lignes Téléphoniques et Télégraphiques (LTT), the ex-ITT subsidiary ef-

Double-duty performance from EROS

Thomson expects that the performance of its new EROS device will suit it for use in half-duplex bidirectional communications links.

Transmitter characteristics are:

- Optical power at 50 milliamperes: 1.7 milliwatts
- Transmission wavelength: 830 nanometers
- Spectrum width at midpoint: 0.4 nm
- Rise time (10% to 90%): less than 15 nanoseconds
- Fall time (90% to 10%): less than 20 ns

Receiver characteristics are:

- Sensitivity for 18.2-volt reverse bias: 0.7 ampere/watt
- Sensitivity for 5-V reverse bias: 0.05 A/W
- Dark current for 18.2-V reverse bias: 25 nanovolts
- Rise time (10% to 90%): less than 1 ns
- Fall time (90% to 10%): less than 1 ns

fectively controlled by the Thomson telecommunications subsidiary, LMT.

The firm is pushing its fiber-optic work with the aim of becoming a major market factor as optical transmission moves into communications. It is developing the phase separation and leaching production of medium-performance fibers. Other work includes: active components operating at 1.3-μm instead of 0.85-μm wavelengths, giving higher reliability and longer links through lower attenuation; single-mode fibers for very high bit-rate systems; and integrated optical components and devices. □

Japan

Microprocessor-based office computer has mini capabilities, easy-to-use operating system

Minicomputer capabilities from a microprocessor chip set and a tutorial operating system intended for unskilled users will make a new Nippon Electric Co. business computer more than just another pretty face around the office. Three models in the new line use NEC's recently developed 16-bit metal-oxide-semiconductor microprocessor that can operate at speeds as high as 10 megahertz.

For each of the three models, the interactive transactional operating system provides a number of utility programs and has an interface for the company's Distributed Information-processing Network Architecture (DINA). Thus each of the System 100 model 80's 16 work stations can function as a computer console and can work with a large central computer.

Basic costs in Japan for the three models range from $36,000 to $66,000 [*Electronics*, Nov. 9, p. 63]. The new models are intended to compete with IBM's System 34, with the top end offering higher performance, although not equal to that of the new System 38.

MOS chip. The 16-bit μCOM1600 microprocessor [*Electronics*, March 2, p. 63] uses mostly n-channel silicon-gate enhancement-depletion MOS technology. However, n-well p-channel elements provide complementary-MOS circuits for high-speed, low-dissipation drivers for use with capacitive loads.

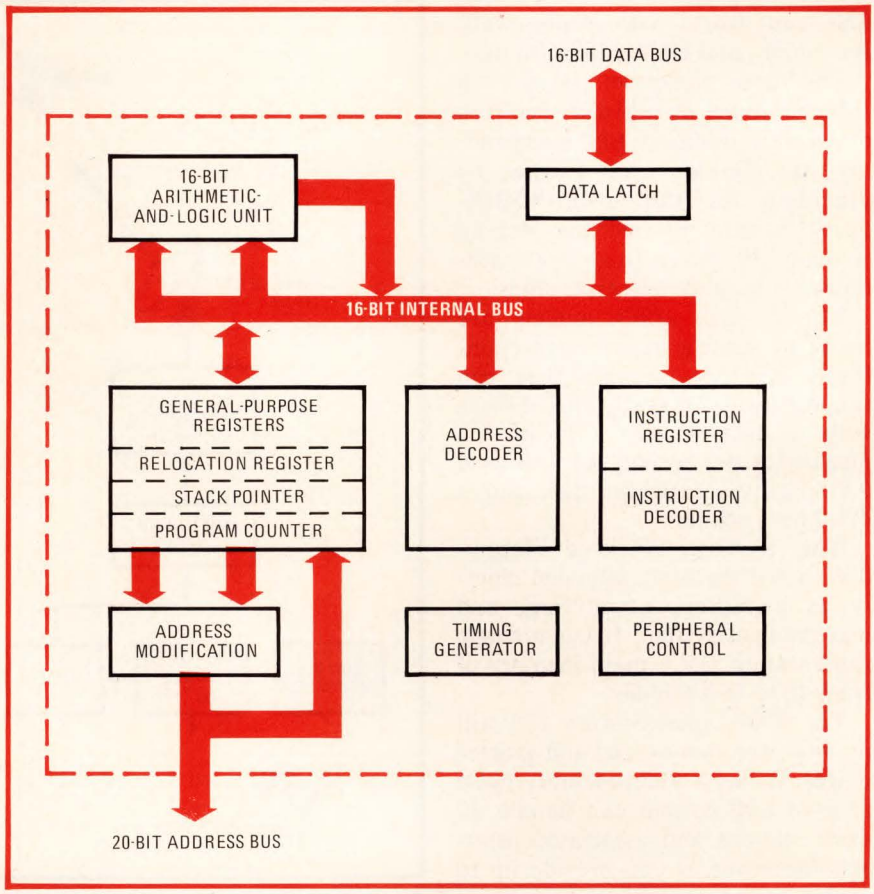
Combining the n-MOS logic circuits and C-MOS output drivers makes for high device density—there are about 15,000 transistors on a 33-square-millimeter effective chip area—and low power dissipation. Total area is 50.75 mm^2.

Normal clock frequency is 5 MHz as in Intel's 16-bit 8086, but NEC claims that operation up to 10 MHz is possible. An effective channel length of 3.5 micrometers yields high-speed, low-power performance and high packing density.

The device's high speed translates into such minicomputer capabilities as a 600-nanosecond register-to-register add time and the ability to address a megabyte of memory. Main-memory cycle time is 800 ns for two bytes, the same as the 8086.

A basic set of 93 instructions is standard, although many additional instructions are available. Also featured are direct memory access, unlimited stack levels, eight levels of vectored interrupt, and 14 general-purpose registers in the arithmetic and logic unit (see figure).

Software. Each of the three models uses the same software, and support is provided for four languages. Business Basic is considered optimum for interactive processing; Cobol 4 is available for batch processing; a high-level version of Cobol provides performance equivalent to that of medium and large computers; and Fortran will



All business. NEC's 16-bit MOS microprocessor, now in the three models of its System 100 business computer, has a main-memory cycle time of 800 nanoseconds.

run technical applications.

An example of the operating system's assistance for inexperienced users is a utility program for report generation and file maintenance. In effect, it displays a menu on the computer's cathode-ray tube. The operator need only select the relevant items for the report or file and then key in the data for each item.

Another utility program, using the Tools-F language, provides formatting and data checking. Working with Business Basic, it can provide the user with logical check, computation and file processing.

The distributed-processing utility program for use with DINA will work with the ACOS series of mainframes made by NEC and Toshiba Ltd. and with IBM and IBM-compatible computers. Such a scheme permits, say, emulation of the IBM 3780 communications terminal for transmission of unit-record batches to an IBM host machine. Moreover, NEC plans to extend the program so that its new line can work with Honeywell, Burroughs, and Univac mainframes.

The three models of the System 100 are aimed at a broad spectrum of users. In addition, NEC is expanding its offerings even further by providing the step-down 8080A-based System 50 and the step-up System 150, which uses 2900-series bipolar 4-bit-slice processor chips.

The System 100's models are ready to muscle in on small-mainframe territory, because they can support two 64-megabyte fixed disks with a data-transfer rate of 1.2 megabytes per second, as well as a 9.8-megabyte cartridge disk and a 400-line/s printer.

The System 50 is a floppy-disk–based machine, intended chiefly as a billing, accounting, and management system. It has a single work station and a main memory of from 40 to 56 kilobytes.

The 2900-based System 150 will provide even more speed and greater power. It has a main-memory cycle time of 600 ns and can handle 32 work stations and associated printers. Moreover, it can provide up to eight communications lines as against the System 100's five.

The 150 can address a 256-kilobyte main memory, expandable to 1 megabyte when 64-K memory chips become available, and up to four cartridge disk units. It can handle a printer operating at 700 lines/s. □

Canada

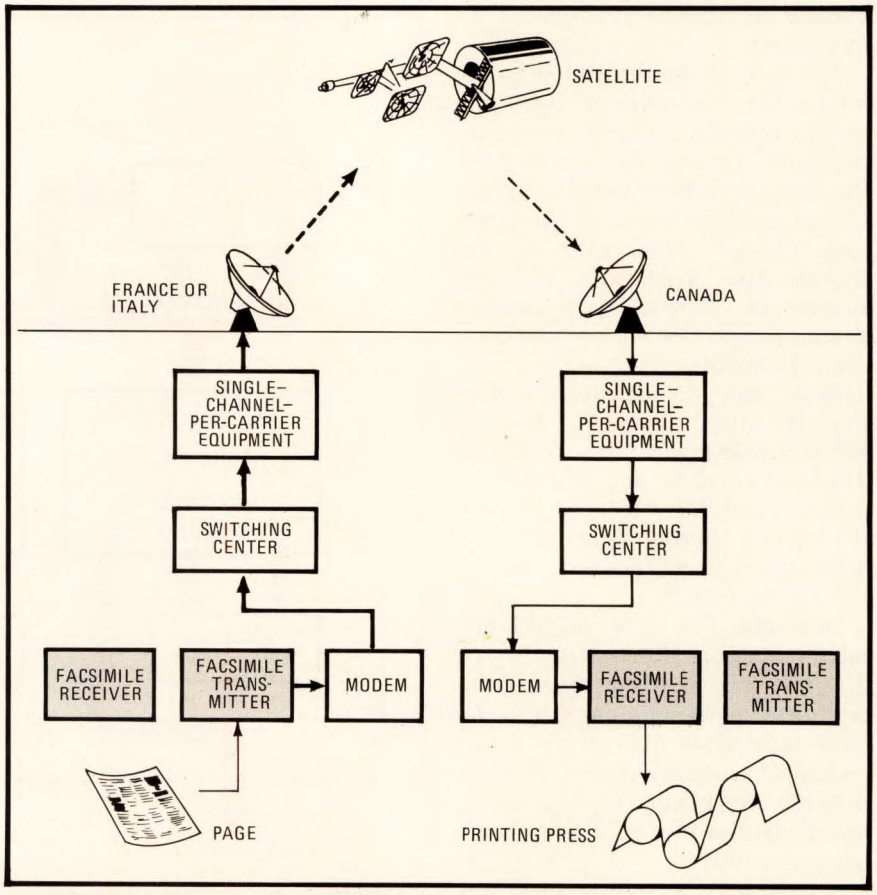
Digital satellite link may speed newspapers from Europe to Montreal for printing

The Canadians want to set up a unique newspaper service, one with same-day delivery from Paris and Milan all the way to Montreal. They will transmit the papers digitally via satellite, much as the Wall Street Journal is sent from editorial offices in New York for same-day printing in cities around the United States.

At stake now, however, is a new kind of international market. "We want to determine whether the large French and Italian communities in Montreal are interested in reading a European paper in their language," says Helmut Styhler, executive engineer at Teleglobe Canada, the quasi-government agency in Montreal responsible for Canada's international satellite communications.

Plans are being negotiated for a six-month marketing trial that will see facsimiles of two dailies, Le Figaro of Paris and Corriere della Sera of Milan, transmitted to Montreal where they will be printed.

"The system transmitted a page of Le Figaro and printed it in the Montreal paper, La Presse, on Oct. 24, 1978, during the Fourth Interna-



Read all about it. Satellite transmission, at either 50 or 56 kilobits per second, could flash facsimiles of European newspaper pages to Montreal, where they will be reprinted.

SCIENCE/SCOPE

The first radar designed for both air-to-air and air-to-ground operation gives Navy and Marine pilots flying the F/A-18A Hornet more operational flexibility than previously available in a fighter/attack aircraft. This all-digital, multi-mode AN/APG-65 system offers all air-to-air capabilities, including track-while-scan, dogfight, and missile guidance. It also provides complete air-to-ground or attack modes.

It has an exclusive new air-to-ground feature called "Doppler beam sharpening." This data processing technique provides the pilot with a very-high-resolution ground map. As the antenna points to angles other than dead ahead, the computer breaks each reading into tiny pieces, then assembles it as a map, using the Doppler effect to eliminate background clutter. The radar system was developed by Hughes under contract to McDonnell Douglas.

Laser rangefinders now can be tested accurately on a miniature range (4"x4"x1") that replaces the standard 490-meter outdoor range. Developed by Hughes, Simulated Optical Range Tester (SORT) can surround the laser beam so that the device need never be shut down by atmospheric or safety problems. It can be configured for any laser application, including airborne, and can provide multiple targets.

As the laser is fired into SORT, light travels through a collimator, into a delay module, then to a fiber optic delay line. These delays simulate distance and signal losses normally found on any standard test range. Eventually, a SORT will be in all Hughes laser systems as a quick test of operational readiness.

Career growth opportunities exist at all levels at Hughes Support Systems in Los Angeles for a variety of engineers qualified by degree or extensive work experience. They include: design and development of automatic test systems for major Hughes radar, electro-optical, and laser programs; field engineering posts throughout the U.S. and the world offer travel, autonomy, and responsibility for the life cycle of Hughes electronic systems. Other positions include training customer personnel and publishing technical manuals (requiring people-oriented engineers with strong oral and written communications aptitudes). For immediate action, phone collect (213) 670-1515, ext. 5444. Or send your resume to Professional Employment, Hughes Aircraft Company, P.O. Box 90515, Los Angeles, CA 90009.

Making enemy weapons guide themselves into ghost targets will be the job of an electronic countermeasures system under contract to Hughes from the U.S. Navy. The equipment is designed to protect carriers and other high-value ships against low-flying cruise missiles and other intruders that are difficult to detect. The system takes an electronic image of the target ship as it is sensed by the enemy's guidance radar and then jams or deceives the radar. The weapon consequently guides itself into a false target short of, beyond, or to the side of the real one. The system, called the AN/SLQ-17A(V)2, consists of an antenna and related equipment on each side of the ship, with a minicomputer and display equipment in the ship's combat center.

Creating a new world with electronics

HUGHES

HUGHES AIRCRAFT COMPANY

tional Conference on Digital Satellite Communications in Montreal," Styhler says.

"Our system is more flexible than the one used for the one-time newspaper transmission experiment between Lyon, France, and St. Louis earlier this year," he continues "because we can handle both 50- and 56-kilobit-per-second rates. These are required for compatibility with both the French and the Italian data rates. We expect regular service within six months."

The connection. The transmission starts at the European newspaper site, where a standard reproduction proof of a page is prepared by the editorial staff. This is converted to an electronic facsimile, processed by a digital data-compression technique, and converted to analog format for transmission to an international switching gateway.

From there, it is relayed over cable or microwave facilities to the earth station in Bercenay, France, or Fucino, Italy, where the analog signal must be changed back to digital for single-channel-per-carrier transmission. An Intelsat IV-A satellite in a geostationary orbit picks up the signal and beams it to Teleglobe's Mill Village station, which is in Nova Scotia.

Converted back to analog form, the signal next is sent to the Canadian international gateway in Montreal via microwave transmission, then to a modem that reconverts it to digital form, and then to a data reconstructor that removes the effects of the bandwidth compression.

Finally, the reconstructed signal controls a laser in a facsimile recorder to recreate the newspaper page by exposing a sheet of photographic film. The film is developed and used to produce a printing plate facsimile.

The technology employed—for example, the Pagefax 660 transmitter and 661 receiver made by Muirhead Ltd., Kent, England—is all state-of-the-art, Styhler notes, but very reliable. The estimated system bit error rate of 1 part in 10^6 is more than adequate for quality transmission, and the system "could go into operation with little effort," he says. □

Great Britain

Impatt-diode amp aiming at TWTs

Yet another vacuum-tube device that may fall victim to advances in solid-state technology is the traveling-wave tube used in microwave radio relay links. For its planned 11-gigahertz digital radio relay system, the British Post Office is testing a solid-state amplifier using high-efficiency Impatt diodes with an 8.4-watt power output.

William Thorpe and Peter Huish, BPO engineers at the Martlesham Research Centre, Ipswich, are confident that improvements in diode performance will soon give a 10-W output, competitive with that of TWTs. Bandwidth for their new amplifier at a gain of 6 decibels is 260 megahertz, and the power-added efficiency is 19%.

Traveling-wave tubes have a limited lifetime, says Huish, so the BPO researchers decided to look into alternatives. The new amp is intended to fit into a microwave system using TWTs, now at the prototype stage at General Electric Co. Ltd.'s Hirst Research Center. Field trials of the TWT-based equipment will start next year. If all goes well, the production version could use the Impatt amp.

Multichip bonding. To obtain the necessary outputs with an acceptable life of 10 million hours, a low diode junction temperature was essential. It is achieved with a multichip bonding technique.

The BPO setup uses Impatt diodes developed at Martlesham. In the present device, two active areas are bonded onto a gold-plated silver stud with a ceramic ring sidewall. The result is a single diode with an output of between 3 and 5 W. Two of these diodes are used in the Impatt amp for the digital radio link.

An important consideration was achieving the 4-ohm internal resistance at which Impatt oscillation occurs, while at the same time matching the oscillator output into a 50-ohm external circuit. So Huish and Thorpe used a combiner circuit originated by C. T. Rucker.

The circuit is a length of coaxial trough line capacitively coupled at its center to a 3-millimeter coaxial cable. The diodes are mounted axially at either end of the line. A stabilizing resistor is incorporated at the line's center in order to inhibit parasitic oscillations.

The circuit is tuned by adjusting the length of each trough-line section and is series-resonant when each section is half a wavelength. Fine tuning is done by adjusting a quartz-tipped screw in the trough line. The dc bias is fed separately to the chips through a high-impedance coaxial choke feed.

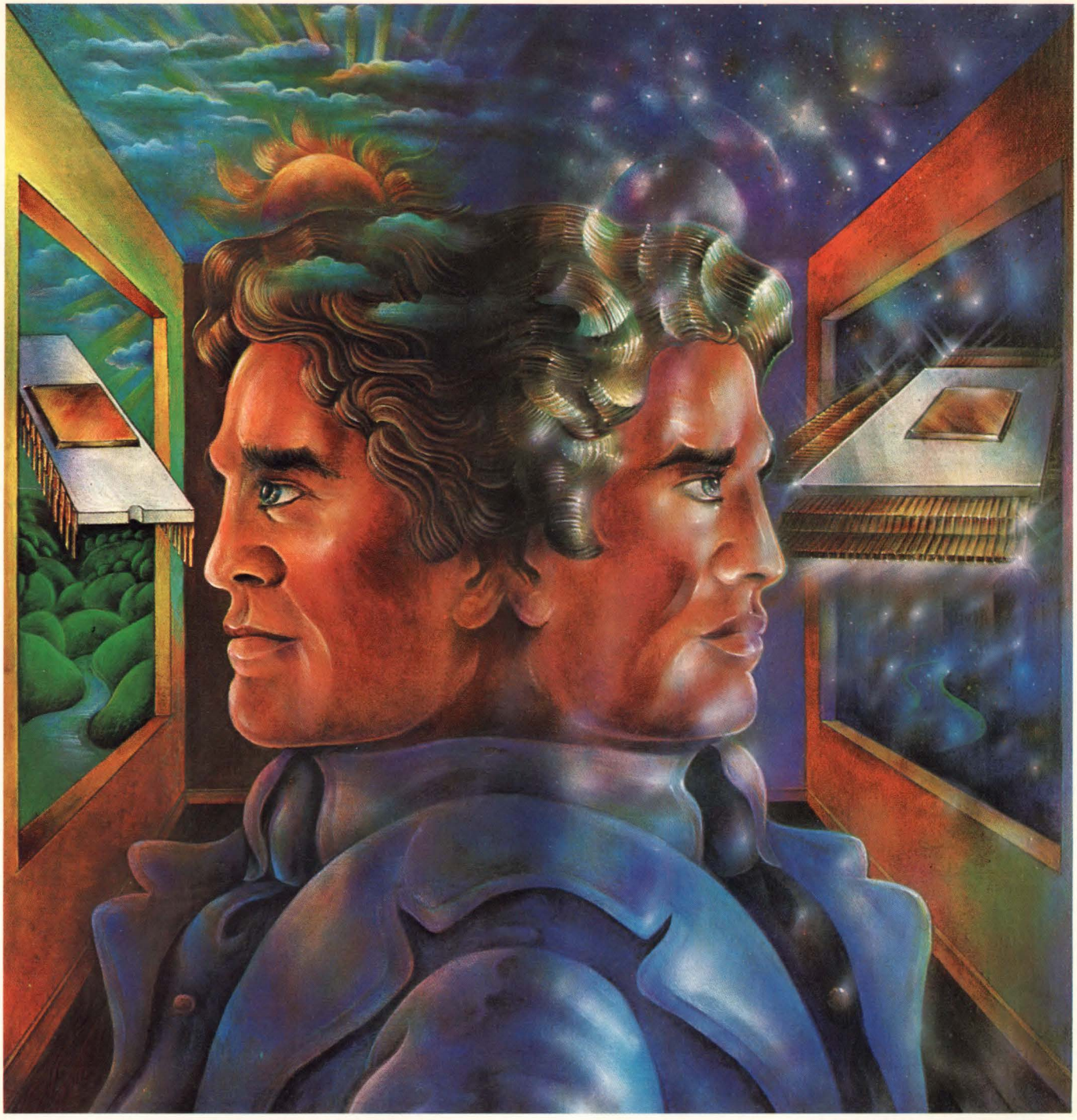
Cascaded systems. The resulting 6-dB system gain is not comparable with the 10-dB gain of a TWT system, but two Impatt stages can readily be cascaded to give the necessary output, Huish says. For the likely length of most links in the system, a 5-W output probably will suffice.

To fill out the full bandwidth between 10.7 and 11.7 GHz, as planned by the post office, would take four of these systems. Usually, the bandwidth will be split into two 500-megahertz channels, and each channel will have a 250-MHz path in each direction. Thus, for full-bandwidth utilization, four amps would be necessary.

The resulting setup would provide at least six data channels at 140 megabits per second. This 11-gigabit digital transmission system could be built onto the BPO's existing analog network, using the same radio towers and ancillary equipment.

Package inductance initially restricted the upper operating frequency. It turns out that the inductance is set by the thickness of the diode as well as by the dimensions of its ceramic package.

In the final version the ceramic is reduced to 0.015 in. and strict control is exercised over the thickness of the diode chips to prevent variations in their impedance between batches. The length of the trough line is adjusted to give a center frequency of 11.2 GHz. □



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The Sentry VIII with its 120 fully programmable I/O pins will meet today's LSI requirements, and be ready to take on your VLSI testing later. But, let's take a look at some of the things the Sentry VIII can do for you right now.

Testing complex devices? The Sentry VIII will routinely perform precise characterization of microprocessors, peripheral chips, bit slices, RAMs, ROMs, shift registers, UARTs and digital hybrids in technologies such as NMOS, PMOS, CMOS, SOS, ECL, TTL, and I^2L.

Multiple pass testing? Chances are, you're occasionally forced to do some multiple pass testing of complex multi-pin devices. Well, the Sentry VIII can eliminate that extra pass. It has the ability to change any pin or timing assignment (input, output or format) on the fly. That can represent a tremendous improvement in throughput and can save as much as 50% of your testing time.

Still testing devices one at a time? By multiplexing the 120 fully programmable I/O pins on the Sentry VIII you can test two, even three, LSI devices simultaneously. Another 50% to 60% savings in test time.

And you can save even more. To provide lower operating costs, the Sentry VIII features multi-task (foreground/background) software for simultaneous compiling, editing and testing; a CPU that provides 50 to 200% faster throughput; a sequence processor to handle high complexity devices; and a pattern processor to tackle the largest memories.

Still don't think you're ready for a true 120-pin tester? Maybe you'd better think again.

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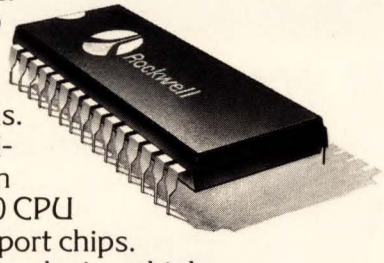

Micropower is also telecom devices, high speed data micromodems, SAWD and mechanical bandpass filters, custom MOS, military MOS and custom subsystems. And now bubble memories.

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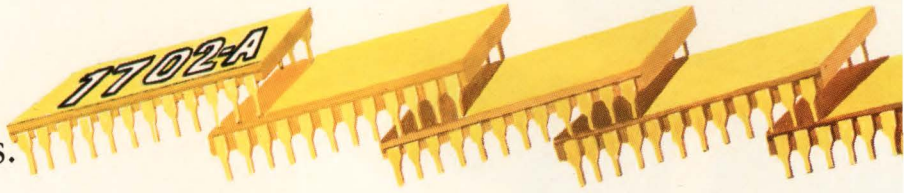
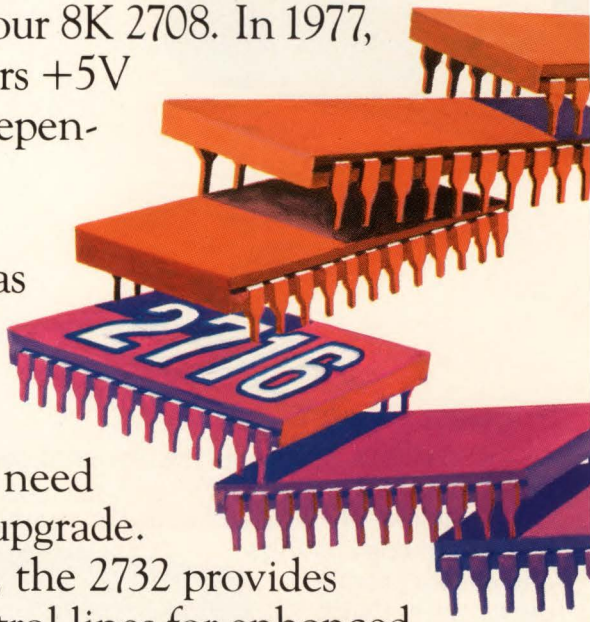
Intel's EPROM the 2732 simplifies



Frankly, EPROMs exist to support microprocessors. That's the basis of Intel's EPROM evolution: At each higher level of density and performance, the industry standard is chosen for its compatibility with current microprocessor designs. We followed this principle when we introduced the first EPROM, our 2K 1702, and again with our 8K 2708. In 1977, Intel's 16K EPROM, the 2716, gave designers +5V only operation, low standby power and independent bus control they needed to take full advantage of 5V microprocessors.



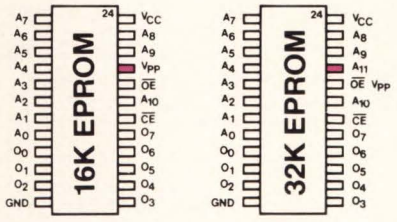
Now Intel introduces the 32K 2732. It has all the advantages of our industry standard 2716 with twice the density and no compromise in performance. And since it's totally compatible with the 2716, you don't need jumpers when you upgrade.

Most importantly, the 2732 provides two independent control lines for enhanced performance in today's new multiplexed microprocessors. Chip Enable (pin 18) controls active and standby power dissipation and is used as the device selection pin. Output Enable (pin 20) allows the microprocessor to maintain control of the system bus to prevent bus contention. Using independent controls is your link to higher system performance and future system compatibility.

Designing with the 2732 means flexibility, too. It's a +5 volt part, so you can design your entire system—CPU, peripherals, RAMs and EPROMs—around a single +5 volt supply. And with maximum

Evolution and how microcomputer design.

current of only 150 mA, the 2732 offers lower power per bit than any other EPROM. In standby, current is reduced 80%, to 30 mA maximum.



	2716	2732
Organization	2K x 8	4K x 8
Power Supply (V_{CC})	5V	5V
Active I_{CC} (max.)	100 mA	150 mA
Power per bit (max.)	32 μW/bit	24 μW/bit
Standby I_{CC} (max.)	25 mA	30 mA
Access (max.)	350-450 ns	450 ns

Because foresight and flexibility at the design stage can extend a product's life cycle by years, we've written a comprehensive application note, AP30, on using EPROMs in 5V microprocessor systems. AP30 tells you how to get the best performance from today's EPROMs and how to design for easy mobility to tomorrow's higher density devices. For a copy of AP30 and our 2732 data sheet, contact your local distributor or write Intel Corporation, 3065 Bowers Ave., Santa Clara, California 95051.

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Circle 79 on reader service card

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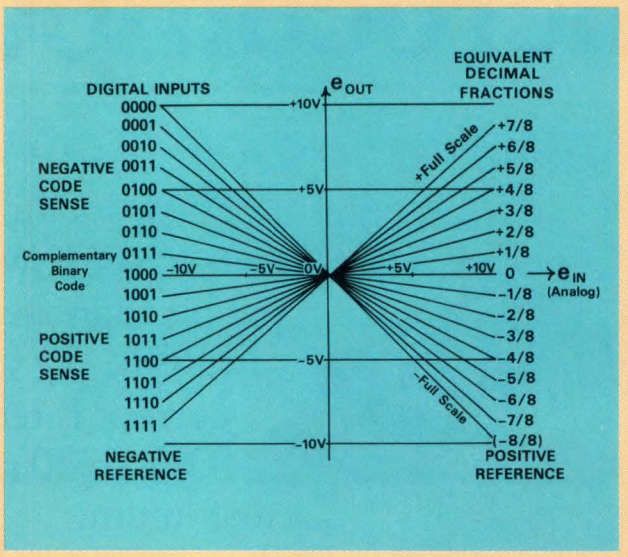
OUR AD7533 10-BIT, $6 CMOS MULTIPLYING CONVERTER BREAKS THE PRICE BARRIER.

In five short years, the price of our monolithic CMOS 10-bit multiplying DAC has been reduced dramatically. From $18 in 1973 to $13 in 1976 to an unbelievably low $6 today. With no sacrifice in performance. It's all due to the optimization of the CMOS processing technology which allows maximum circuit density on the chip. $6 in 1000s today. In 1982?

PRICE ALONE COULD CONVINCE YOU BUT THINK ABOUT THE APPLICATIONS.

The price. $6 in 1000s for a 10-bit CMOS multiplying DAC is a tremendous breakthrough. And the applications are almost limitless. Digitally controlled gain or attenuator circuits, synchro-to-digital converters, and ratiometric low-power A/D converters, as well as digitally controlled power supplies, to name a few.

In addition, single-chip construction inherently offers vastly improved reliability over multi-chip hybrid designs. This allows us to offer high reliability versions fully screened to MIL-STD-883A, Class B.



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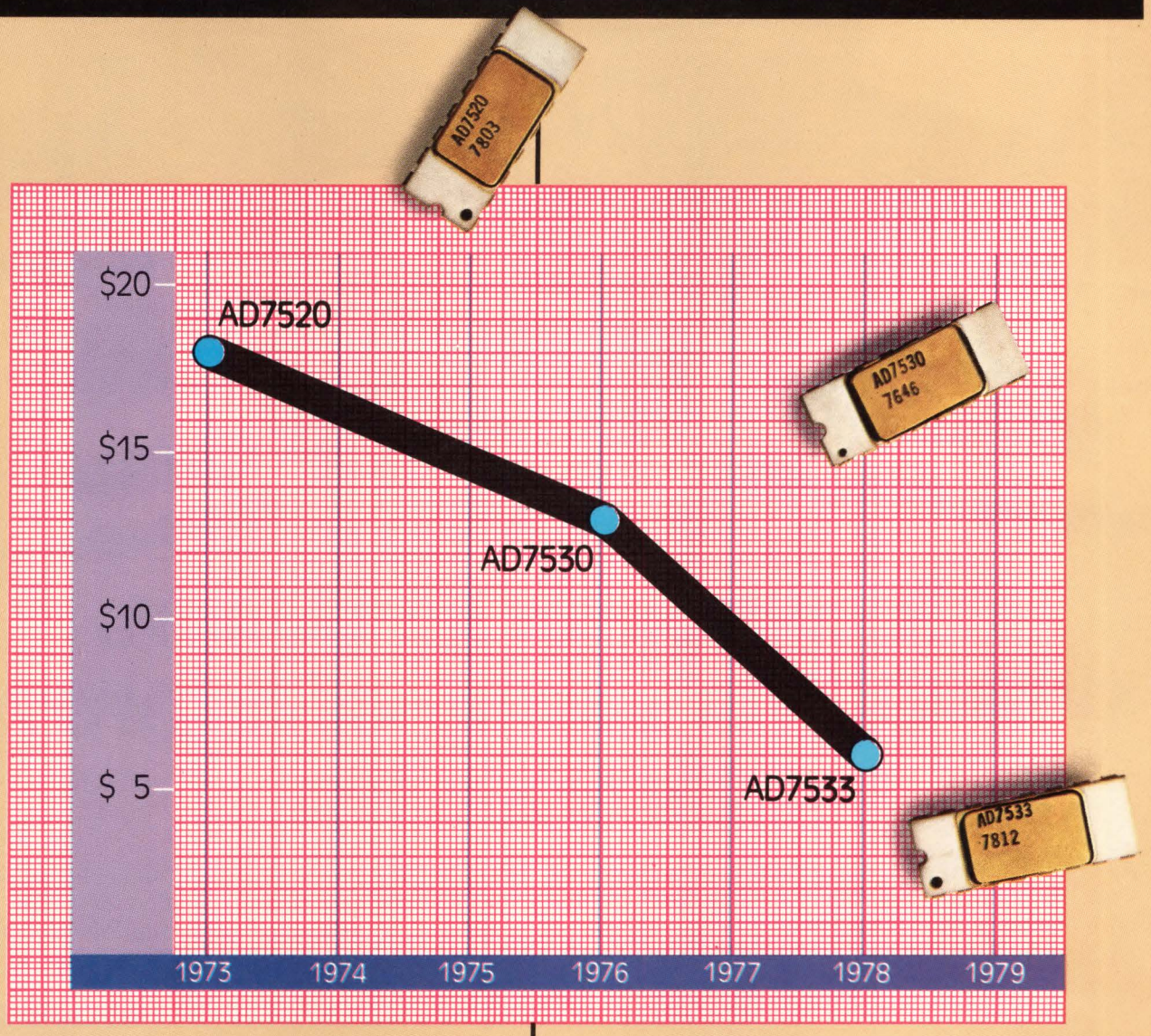
The AD7533 10-bit CMOS multiplying DAC is not your ordinary DAC. It contains CMOS switches and the logic to drive them and a thin-film-on-the-chip R-2R ladder network. The result is a digitally controlled attenuator with 10-bit conversion linearity and even better inherent analog linearity, with very low feedthrough to frequencies beyond 50kHz.

Beyond its ordinary converter applications, it's a 4-quadrant multiplying DAC or a digital pot. This means it accepts variable references. So it can be used to modulate an analog signal by a computer output. Or an M-DAC with front-panel thumbwheels can replace conventional pots.

The price is down. The potential is up. For complete specs and information, call Doug Grant at (617) 935-5565. Analog Devices, Inc., P.O. Box 280, Norwood, MA 02062.

DACS WILL COST IN 1982.



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Boschert power supplies are perfect for microprocessor-based systems and other digital equipment because they're five times smaller than comparable linear supplies, and nine times lighter. Because little power is wasted as heat, they require no fans — only convection cooling. And Boschert switchers are well-suited for high pulse-load environments such as printers: when additional power is required, it is available instantaneously — at any output.

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AT&T has 350 pages of answers

Reply to FCC's request for data on ACS brings industry calls for more; meanwhile, Xerox files telecommunications plan of its own

by Anthony Durniak, Computers Editor

Like a striptease artist, American Telephone & Telegraph Co. is slowly lowering the veils of secrecy that surround its proposed digital Advanced Communications Service. But, as might be expected, an eager audience of computer and communications companies is calling for AT&T to reveal more.

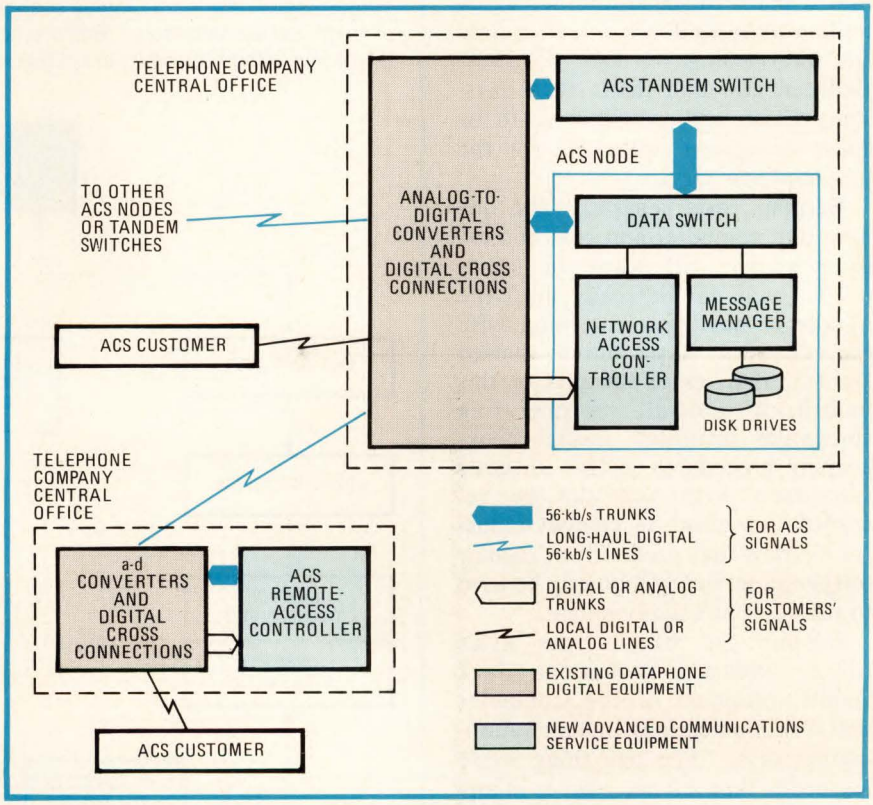
Details of the switched digital ACS, which will allow dissimilar computers and terminals to communicate, were sketchy in the original filing to the Federal Communications Commission last summer [*Electronics*, July 20, p. 41; Aug. 3, p. 79]. So, in response to some 140 questions posed by the FCC, AT&T late last month filed more than 350 pages of answers, of which some provided new technical details and others merely repeated earlier documents. And although AT&T asked the FCC to waive the requirements for a traditional section 214 filing for a new service, it filed one just in case.

AT&T's reply came just as Xerox Corp., Stamford, Conn., was filing its proposal to enter the telecommunications business (see "Xerox has a plan, too"). Although ACS is seen as competing with both Xerox' proposed system and Satellite Business Systems' venture (in which IBM is a partner), Bell said in its filings that it has no plans to handle digitized voice, a capability both other systems will offer.

Details. Redundant minicomputers apparently will be the common element in the design of the ACS nodes and switches, although AT&T does not specify model numbers or capabilities. The tandem switches, used to connect the various nodes, and the data switches, used to format and manage the data packets, will each consist of dual minicomputers. The message-manager portion of the node will also have independent dual disk drives, with messages duplicated and stored on both disk systems. Redundant microprocessors may replace the minicomputers in some of the network-access controllers and remote network-access controllers, AT&T says, although again it does not say which ones.

In its replies, AT&T also explains that all ACS nodes, tandem switches, and even remote network-access controllers will be located at the operating company's central offices, not on customers' premises. There they will be connected to the digital cross-connectors, multiplexers, and other transmission gear already installed for the currently offered Dataphone digital service. AT&T notes that any of the existing digital trunk lines or switches it takes over to use for ACS will be dedicated to the new service, rather than switched back and forth between ACS and other services.

The current regulatory battle over whether or not AT&T should be allowed to offer ACS revolves around



Something old, something new. AT&T proposes to put ACS gear at central offices, which already hold digital switches and a-d converters for Dataphone Services.

whether the service constitutes data processing, an area the phone company is prohibited from entering. Opponents of the plan say that the message-preparation and editing functions and the network-programming language proposed for ACS by AT&T do indeed constitute data processing.

In the new documents, AT&T repeatedly calls the functions of the various computers used in ACS "communications processing" and says network-control languages "are specifically designed for customization of message preparation, movement, and delivery." Because of that, AT&T says "it is unlikely that customers would attempt to program or reprogram their data-processing programs into languages suitable for communications customization functions." And AT&T claims that ACS' message-storage facilities will lack the data-base management capabilities needed for data or program storage.

The telephone company says that by July it had already spent some $12.5 million to develop ACS and that it plans to spend another $25.4 million to finish development in time for an opening on Oct. 1, 1979. Between now and then, AT&T says, some $35.5 million will have to be spent on capital equipment for the proposed new service.

Keeping costs separate. The one item that computer and communications firms still want to see—tariffs—will not be ready until the middle of next year for filing with the FCC, AT&T says. But it assured the FCC that, as of the first of this month, it and all its operating companies instituted special bookkeeping procedures so that all costs associated with ACS can be recorded—an effort to combat industry charges that profits from regular telephone service will quietly be used to subsidize ACS development.

Despite the size of the AT&T filings, industry spokesman Jack Biddle, president of the Computer and Communications Industry Association says, "The one thing we've learned is that it's not what is in any AT&T document that counts, it's what's not there." Adds Biddle: "There's nothing there that specifically states they won't sell ACS as a data-processing service, and I see nothing technically that prevents them from offering a full range of such services." In fact, he is afraid that AT&T documents may be too large. "I get the feeling somebody is trying to wear me down to the point where I can't see the trees for the forest."

In any case, this is not the last word on ACS. The FCC has asked concerned parties to file their comments on it by Jan. 5, after which it will give AT&T until Feb. 16 to respond, then give other parties a last shot until March 6. □

Xerox has a plan, too

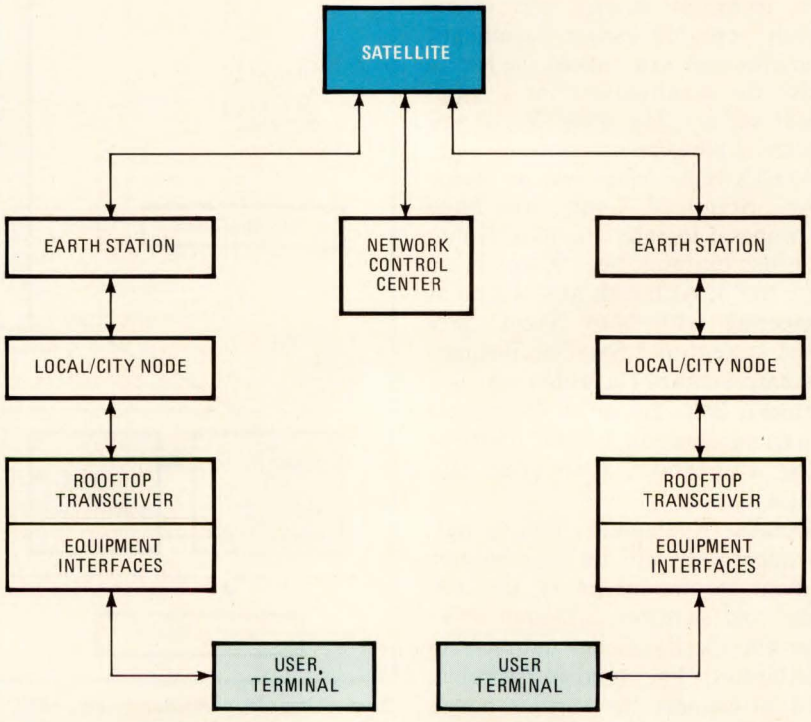
"We can do it too—and better" is the message from Xerox Corp. about implementing the office of the future. And it has come up with yet a third method to add to the two techniques heretofore planned—Bell System's terrestrial telephone approach and IBM's satellite/earth-station link.

Customers of Xerox's proposed Telecommunication Network (called XTEN) would have their messages move from an office electronic terminal through Xerox-supplied equipment to a rooftop antenna and beamed by microwave radio to a multisubscriber collection antenna. From there, the digital information would be sent to an earth station and beamed to leased satellite channels for transmission to another remote earth station.

Xerox has asked the FCC to allocate spectrum space in the 10-gigahertz band for the terrestrial part of XTEN and notes that "competitors could use the band for the same purposes." The company does not seem to be worried about proper labeling of its service. For Bell, that is a big problem since, as a regulated monopoly, it is sensitive to charges that its service will engage in computer-like data-processing activities. The service would also serve small customers, unlike the Satellite Business Systems' scheme in which IBM is a partner, because the local microwave links are relatively inexpensive and to a large extent will be shared.

Digital technology will play a large part in determining the price structure for all three contenders in what promises to be the most lucrative communications market of the 1980s. And XTEN's general manager, Burton G. Tregub, sees new technologies such as fiber optics making price predictions a "high-risk undertaking." Bell's recent introduction of a fiber-cable–linked telephone with no bandwidth limitations would seem to bear this out.

Harvey Hindin



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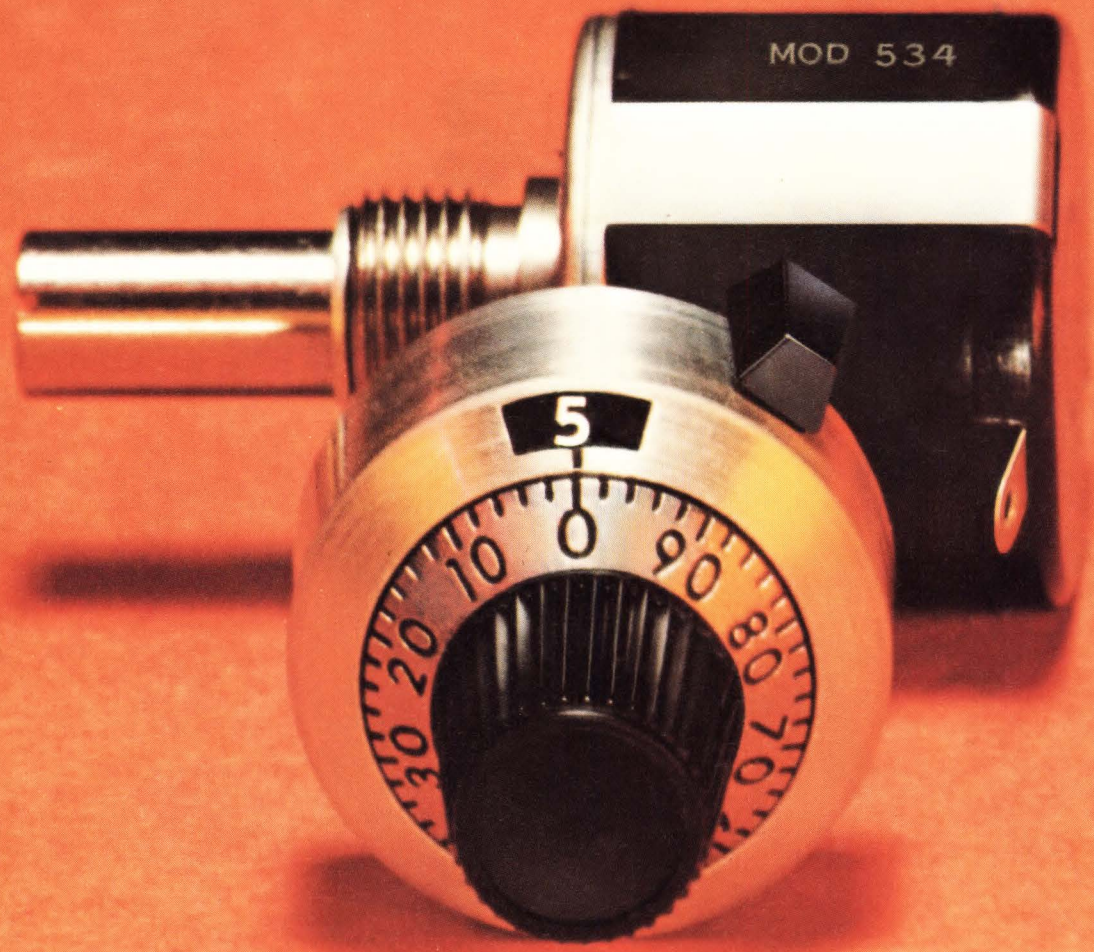

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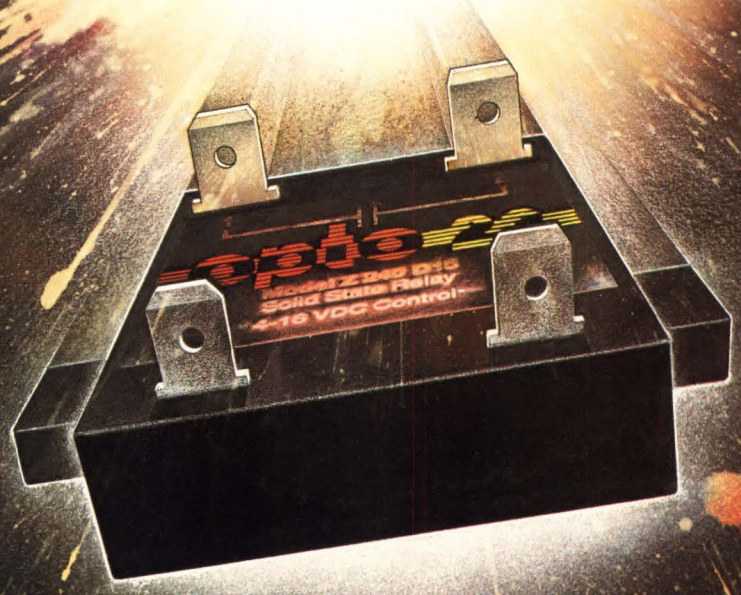

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Circle 86 on reader service card

Electronics abroad

For Britons, 1979 may be déjà vu

With unions driving for double-digit raises, New Year could bring return to familiar inflation economy

by Kevin Smith, London bureau manager

In the year ahead, the British very likely will get a sinking feeling that they have been through it all before. The more militant unions appear set to trigger a round of double-digit pay rises—Ford workers have won 17%—and that inevitably means a spurt of inflation. To get prices back under control, James Callaghan's Labour government, or its successor, will inevitably turn to the stop-go cycles that have stifled growth for most of this decade.

In 1978, at least, Britons had pounds aplenty in their pockets and, with inflation under control, did not mind spending them. The mild consumer boom, abetted by rising revenues from North Sea oil and a stronger pound sterling, fueled a 3% gain in the gross domestic product, the first respectable rise in some years. Some economists think 1979 will be a reasonably good year. Others see a sag to something like a 1% growth rate.

Unless there is a surprising "go" for the economy overall, the country's electronics markets will grow more slowly next year than they did this year. *Electronics'* annual survey points to equipment markets of $5.163 billion in 1979, up 10.7% over an estimated $4.662 billion for 1978. That is appreciably below the 13.6% gain logged this year.

The trend holds for components markets. They are predicted to move up to $1.826 billion, a rise of 7.8% over 1978's $1.693 billion, but well below the 10.5% increase for 1978. (Throughout this report, 1 pound sterling equals $1.95.)

Entertainment. Britain's native television set makers, though plagued by overcapacity and a saturated market, can probably count on another year of grace. After a slow 1978 start color-TV sales picked up in the second half and should wind up at some 1.85 million units—far better than most set makers expected. And there is improvement in sight for 1979, predicts Nigel Schofield, a market analyst at Thorn Consumer Electronics Ltd., the largest UK TV producer.

Computers. Even if the overall economy shows more stop than go in 1979, computer makers should fare better than their setmaking brethren in Britain. *Electronics'* survey points to a solid 14.3% rise for computers and related hardware next year, putting sales at $1.455 billion. To be sure, the rise is a little under the estimated 15.8% gain in sight for this year, but no one is particularly concerned. "Our business is anticyclic," maintains Terrence Stones, director of planning for Honeywell Information Systems Ltd.

The underlying growth trend is strong in all sectors, reports Peter Aylette, marketing manager at International Computers Ltd., the largest native computer company. Like everyone else, he sees the spectacular growth coming from the bottom end of the market: minicomputers, small business computers, terminals, and the like. "The point-of-sales market looks as if it is going to take off," he adds, and there will be some action in word-processing.

Communications. The buzz word at communications-equipment makers in Britain right now is "System X." Industry insiders think that the British Post Office has approved contracts for the first two System X exchanges and wants to cut them

BRITISH ELECTRONICS MARKETS FORECAST
(IN MILLIONS OF DOLLARS)

	1977	1978	1979
Total assembled equipment	**4,105**	**4,662**	**5,163**
Consumer electronics	1,343	1,542	1,702
Communications equipment	1,079	1,224	2,338
Computers and related hardware	1,098	1,272	1,455
Industrial electronics	274	296	316
Medical electronics	163	186	193
Test and measurement equipment	104	114	128
Power supplies	26	28	31
Total components	**1,532**	**1,693**	**1,826**
Passives	794	872	947
Semiconductors	429	486	525
Tubes	309	335	354

(Exchange rate: $1 = 51 pence; £1 = $1.95)

Note: Figures in this chart are consensus estimates of consumption of electronic equipment obtained from a survey made by *Electronics* magazine in September and October 1978. Domestic hardware is valued at factory sales prices and imports at landed costs.

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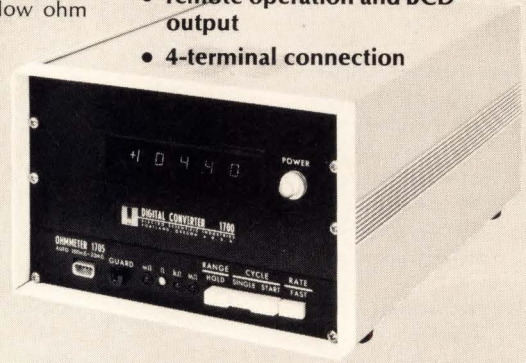

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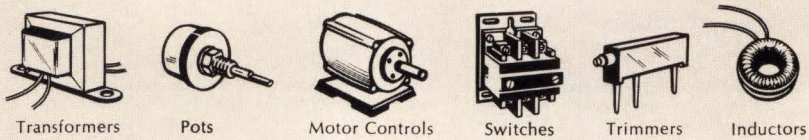

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Probing the news

over in 1981, thus starting on a fully-integrated digital telephone network. Other landmark contracts in sight for 1979 will presumably get Plessey Co., General Electric Co. Ltd., and ITT's Standard Telephone and Cable Ltd. into production of long-haul fiber-optic transmission systems running at 8 and 120 megabits per second.

The System X contracts will give telecommunications producers a clearer idea of what is in store for them over the long run. Meanwhile, the program to install TXE-4 semielectronic exchanges will stimulate. In addition, defense and avionics markets are doing well. All told, *Electronics'* survey suggests a market of $1.338 billion up 9.3% over the $1.224 billion for 1978. True to form, the expected gain falls short of the 11.6% registered this year.

Test and measurement. It seems that the only sector slated for a higher growth rate next year is instruments. It is headed for 12% growth overall, says Tony Davies, who heads Solartron-Schlumberger's British instruments and test equipment division. Davies' assessment comes close to the results forecast in *Electronics'* survey—a 12.2% rise to 128 million. Chiming in is Fred Hutchins, marketing manager for instruments at Gould-Advance Ltd. "All our inputs are that business in 1979 is going to be better than this year—which was reasonable," he says. Gould aims to increase its sales 30% next year.

Components. Ups and downs are the lot in life for components makers. They are in for an up, to $1.826 billion next year from this year's $1.693 billion. But that is a down when translated into growth—to 7.8% from this year's 10.5%

In the mercurial market for integrated circuits, growth next year should run between 12% and 15%, says Michael Young, a market analyst for Texas Instruments UK. That compares with 20% for 1978 and a dazzling 35% for 1977. Despite the slowdown, Young does not foresee a rough price war this time around. "Capacity is still behind demand," he says. □

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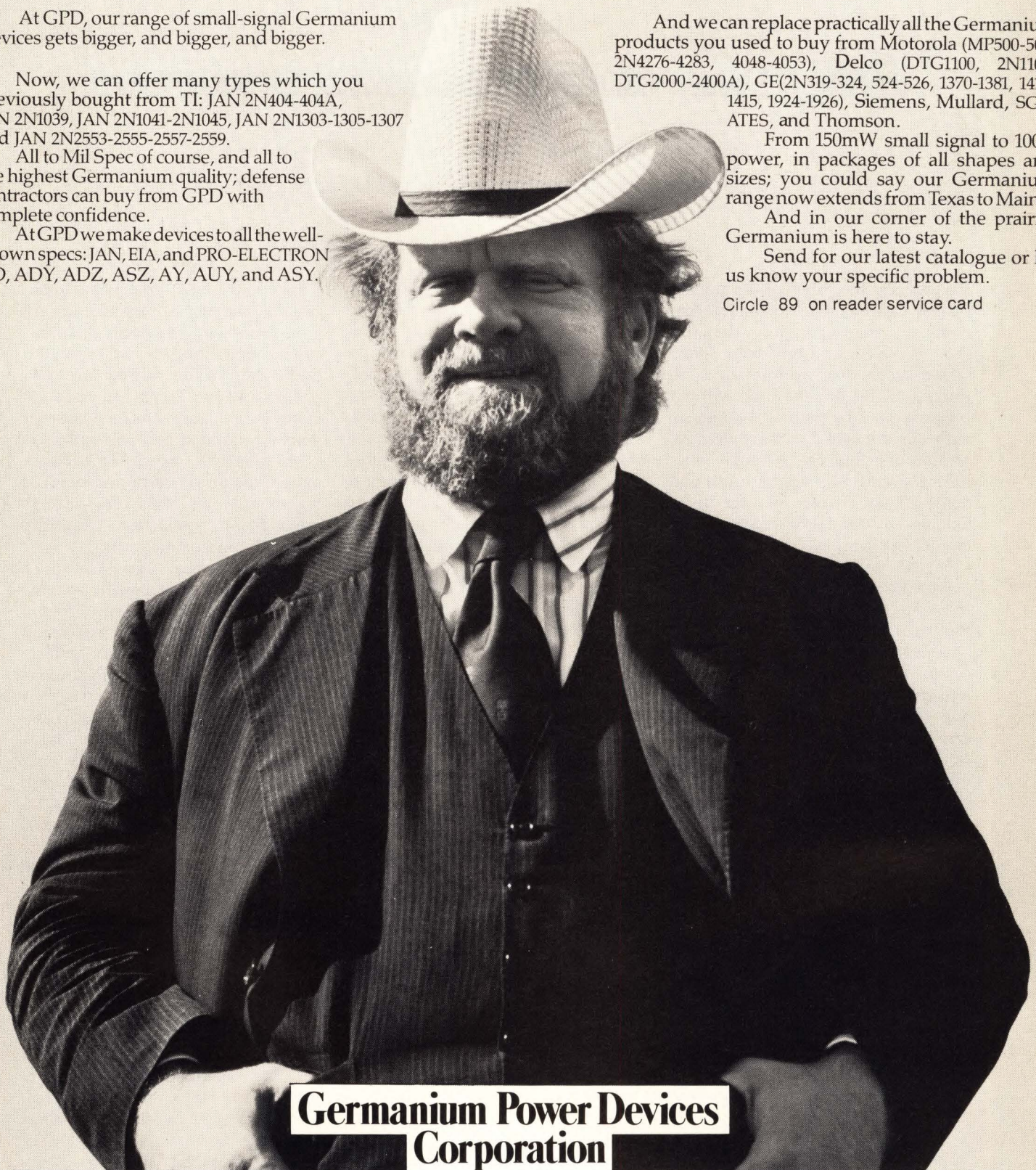

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Military electronics

Programmable processors wanted

Shift from fixed architecture is part of military's drive for faster development and less expensive upgrading

by Robert Brownstein, San Francisco regional bureau

Recognizing the potential for quicker system development and more economical system upgrading, the military is shifting away from fixed signal-processing architectures to programmable designs. This will put pressure on contractors to come up with bus-oriented hardware designs, and on chip makers to supply integrated circuits that are both fast and dense. That is the message from Gomac-78—the Government Microcircuit Applications Conference.

Signal processors are a key to narrowing what some see as Russia's military technology lead because they are found in nearly all weapons and navigational systems. The processors must take in the digital data stream issuing from various sensors and their analog-to-digital converters, perform lightning-fast arithmetic operations on them, and either directly access a digital-to-analog converter or transfer the results to a computer.

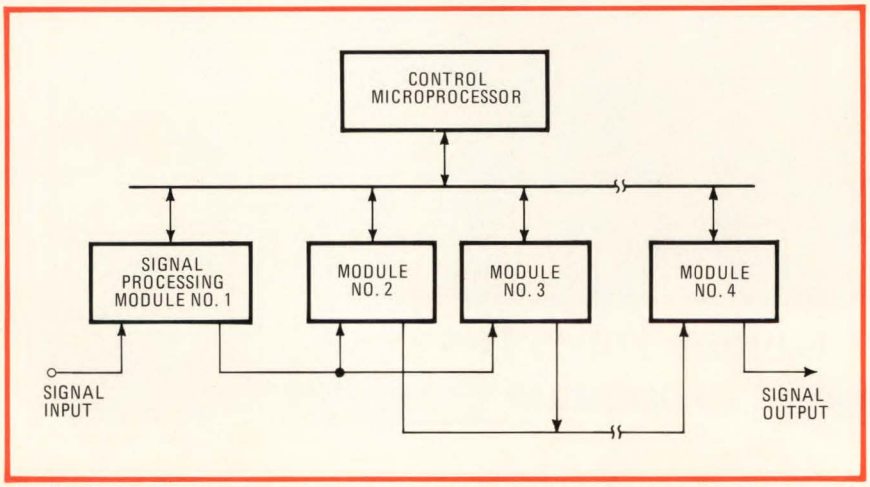
New systems will have to be developed that are less costly and more easily upgraded and can be modified in whole or in part for use by all three services, says Earl E. Swartzlander Jr., signal-processing specialist at TRW Defense and Space Systems group, Redondo Beach, Calif. But this requires processing techniques that differ from those most applicable to general-purpose data processing. "In contrast to data processing, which has been implemented effectively at the large-scale integration level, the demands of signal processing far exceed available devices," he says.

New very high-speed integration or VHSI—a Department of Defense goal—should satisfy signal-processing needs because the requirements spelled out for those chips are the same needed for signal processing: the maximum product of the number of gates per chip times the operating speed of these gates.

But there will be many variations of programmable hardware designs for various signal-processing applications, and not all will favor very large-scale integrated or VHSI circuits, according to Swartzlander. Dedicated systems with flexible data paths and a large number of input/output ports and interconnections do not lend themselves well to VLSI design, he says. "It becomes more difficult to design and produce high-density ICs when they have to provide interconnection flexibility and multiple I/O data ports."

Modules better. However, in a modular signal-processor scheme made up of a central controller and many programmable processing modules, the modules will perform complete primitive operations internally and will need less and slower I/O interfacing than the larger signal processors. It is these modular designs—a compromise in flexibility between hard-wired and large programmable systems—that Swartzlander feels would be best suited to VLSI implementation. In addition to being a more efficient use of VLSI than larger, fixed-application machines, there is another payoff—the hardware could be shared by the Army, Navy, and Air Force.

A third advantage of the modular approach is that whereas the software may not be as efficient as that of the large, programmable signal processor, "it is easier and cheaper to write and maintain," Swartzlander claims. He expects these modules will provide the sockets for some VLSI devices already complete or nearly complete, such as TRW's 16-by-16 parallel analog-to-digital converter, and a discrete Fourier-transform chip with on-board complex and real arithmetics. □



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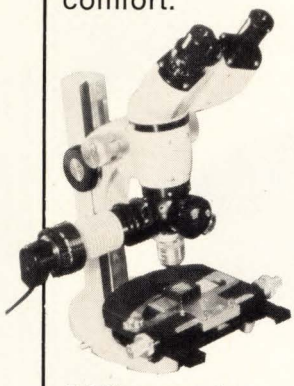

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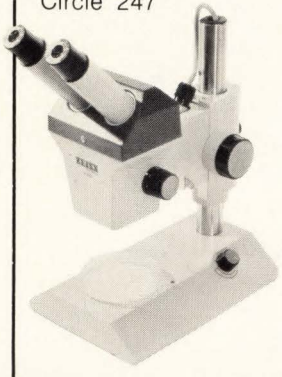

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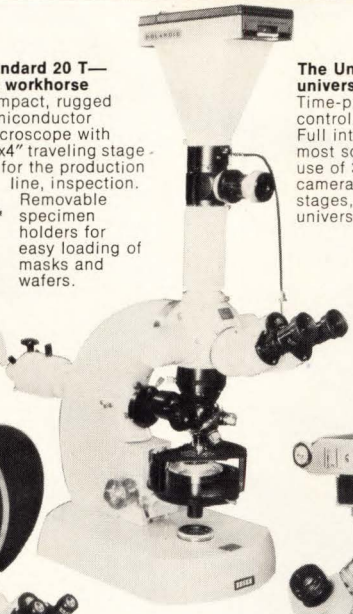

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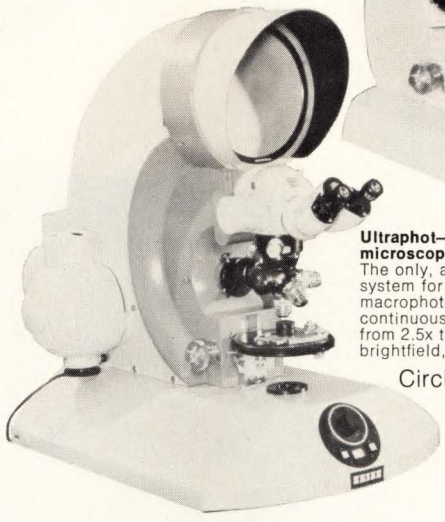

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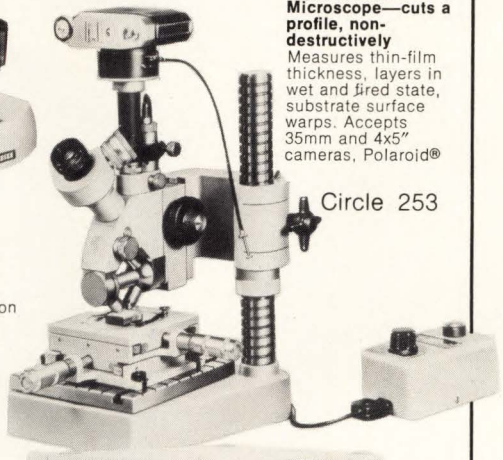

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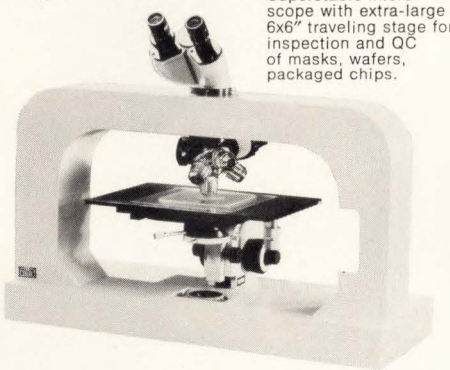

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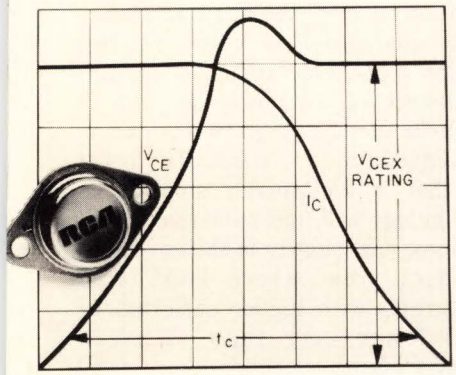

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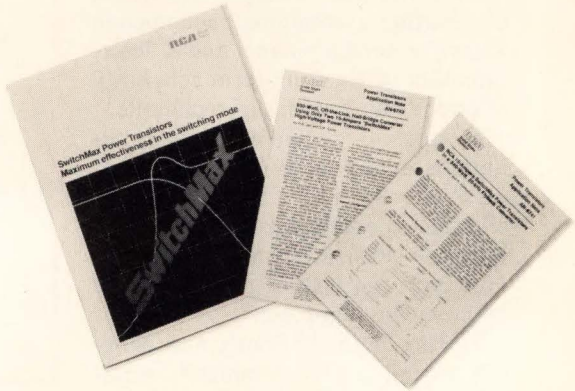
SwitchMax Booklet 2M1217 gives you full details on how these new transistors are designed, made, tested and characterized. There's also a designer's guide chart suggesting optimum transistor types for typical switching power supply circuits.

Application Note AN-6741 describes the use of the RCA 2N6676 15-ampere SwitchMax power transistor as a driven pulse-width-modulated flyback-converter stage, in a 20-kHz off-line power converter providing 340 watts output.

Application Note AN-6743 is a description and analysis of a 900-watt off-the-line half-bridge converter using two 15-ampere SwitchMax high-voltage power transistors. This Note, too, demonstrates the outstanding capabilities of SwitchMax in a typical switching application.

For all this information, contact your local RCA Solid State sales office or distributor. Or write RCA Solid State, Box 3200, Somerville, NJ 08876.

Types	V_{CEV} Rating	I_{CEV} (max) at $V_{CE}=V_{CEV}$ mA	V_{CE}(sat) max at I_C(sat) V	I_C(sat)	t_c(max) at I_C(sat) μs
2N6671 2N6672 2N6673	450 V 550 V 650 V	0.1 (25°C) 1 (125°C)	1 (25°C) 2 (125°C)	5A	0.4 (25C) 0.8 (125C)
2N6674 2N6675	450 V 650 V	0.1 (25°C) 1 (100°C)	1 (25°C) 2 (100°C)	10A	0.5 (25C) 0.8 (100C)
2N6676 2N6677 2N6678	450 V 550 V 650 V	0.1 (25°C) 1 (100°C)	1 (25°C) 2 (100°C)	15A	0.5 (25C) 0.8 (100C)



Circle 93 on reader service card

RCA

Packaging & production

New substrate causes a stir

Porcelain on steel could be key to size and cost barriers of conventional alumina material in thick-film hybrids

by Jerry Lyman, Packaging & Production Editor

For several years, porcelain on steel with a simple conductive pattern screened on has been used in hundreds of thousands of flashbulb arrays made by the General Electric Co. and GTE Sylvania Inc. Now, it is beginning to look like the large-circuit substrate of the future.

This rugged, easily manufactured material overcomes the size and cost limitations of the alumina substrates used for thick-film hybrids. At the same time, it presents an attractive alternative to present printed-circuit laminates, with better power dissipation and a built-in ground plane.

Applications in sophisticated electronic circuitry are just beginning to undergo examination. For example, both E. I. du Pont de Nemours & Co. at its Electronics Materials division at Niagara Falls, N. Y., and Singer Co.'s corporate research and development laboratory at Fairfield, N. J., are in the midst of evaluations of porcelain on steel with glass-based thick-film materials to determine whether it is a usable circuit-board medium.

Early results from both programs do look promising, but there are still problems to be solved. These include minimizing the alkali ion content, eliminating a damaging phenomenon known as brown plague, and a determination of the long-term reliability of circuits built with this technique.

Despite its problems, Trevor Allington, senior product specialist at du Pont, says, "The answer to whether porcelainized steel is a bonafide substrate is a qualified yes. However, the task of proving this is by no means complete."

During both du Pont's and Singer's testing of fired conductive materials on the substrates, a strange and deleterious effect—brown plague—occurred. It showed up as a discoloration of the silver conductors. More serious than the discoloration was the fact that the plagued material affected resistor values and was difficult to wire-bond or solder. Du Pont researchers found that the brown plague could be eliminated by keeping the conductor pattern from coming within 10 mils of the substrate's edge.

Edge cause. Early research by Murray Spector, general manager of materials supplier Alpha Advanced Technology Inc. of Newark, N. J., indicates that the plague may be caused by a strong electric field generated at unrounded edges of a porcelainized steel substrate. The electric field generates silver sulfide in the thick-film silver conductors. To prevent this, the rounding of the edges must be controlled carefully.

Singer's tests turned up interesting data on a comparison of the electrical properties of porcelainized steel and alumina that indicates the new material is not best for all applications. For example, alumina's lower dielectric constant makes it the more attractive material for microwave applications.

Daniel Wicher, a staff scientist at Singer, says, "We have a positive but qualified answer to whether porcelain on steel technology is viable. The qualifications come in two major areas. One is that porcelainized steel will not replace alumina in high-frequency, high-performance, or high-stability systems. The other is that porcelainized steel-based technology will find numerous applications, particularly in the consumer product area, where large area substrates with higher performance and lower cost than standard pc systems are needed." □

ELECTRICAL CHARACTERISTICS OF PORCELAIN ON STEEL VS. ALUMINUM

Property	Conditions	Porcelain on steel	Alumina
Volume resistivity (Ω-cm)	200 Vdc, 25°C	$> 10^{11}$	$> 10^{11}$
Dielectric strength (V/mil)	25°C	900	800
Dielectric constant	1 MHz, 25°C	6.4	9.3
Dissipation factor	1 MHz, 25°C	0.008	0.0003
Loss factor	1 MHz, 25°C	0.07	0.0028

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Memory Address Space	65K	65K	4K	8K	4K	4K	8K
Interrupts — Maskable	Yes	Yes	Yes	Yes	Yes	Yes	No
— Non-Maskable	Yes	Yes	Yes	No	No	No	No
SYNC — Output indicates op code fetch cycle	Yes	Yes	No	No	No	No	No
RDY — Single step and slow memory synchronization	Yes	Yes	No	No	Yes	No	Yes
ϕ_1 Clock Output	Yes	Yes	No	No	No	Yes	No
DBE — Extended Data Bus Hold Time	No	Yes	No	No	No	No	No

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Circle 95 on reader service card

The Riddle of Linear Wonderland:

Do you like the bi-FET op amps you get or do you get the bi-FET op amps you like?

© PMI 1978

Lewis Carroll knew that words can be manipulated so that they don't always mean what they appear to mean. More than 100 years ago (long before anyone started writing about bi-FET op amps) he tried to teach Alice the importance of meaning what you say. Or saying what you mean. It happened at a Tea Party in "Alice in Wonderland" but it could have happened at any meeting in Silicon Valley at which bi-FET op amps are being discussed.

Alice: "I'm glad they've begun asking riddles—I believe I can guess that."

"Do you mean that you think you can find out the answer to it?" said the March Hare.

"Exactly so," said Alice.

"Then you should say what you mean," the March Hare went on.

"I do," Alice hastily replied, "at least I mean what I say—that's the same thing, you know."

"Not the same thing a bit!" said the Hatter. "Why, you might just as well say that 'I see what I eat' is the same thing as 'I eat what I see'!"

PMI noticed that circuit designers liked the bi-FET op amps they got from Tweedle Dee and Tweedle Dum, but decided they could be improved. That's what we've done with the OP-15, OP-16, OP-17, which are the first precision pin-compatible versions of the 355A, 356A and 357A, respectively. Now, you can get what you like!

Read these specs and then ask yourself; is liking what you get the same thing as getting what you like?

OP-15/LF-355, OP-16/LF-356, and OP-17/LF-357 Comparison Chart

Parameter	LF-355A	OP-15E	LF-356A	OP-16E	LF-357A	OP-17E	units
Bias Current, Max., (warmed up) 0°C to +70°C	8.0	0.75	9.0	0.9	9.0	0.9	nA
Slew Rate, Min.	3	10	10	18	40	45	V/μsec
Gain-Bandwidth Product Typ.	2.5	6.0	4.5	8.0	20	30	MHz
Supply Current, Max.	4	4	10:356A	7	10:357A	7	mA
Voltage Gain, Min.	50	100	50	100	50	100	V/mV

Now, without going back to double check, what three major improvements in performance did you find in those specs?

In case you missed them, we'll tell you:

1. Higher speed—by a factor of two.
2. Reduced offset voltage, thanks to our production-proven zener zap trimming technique.
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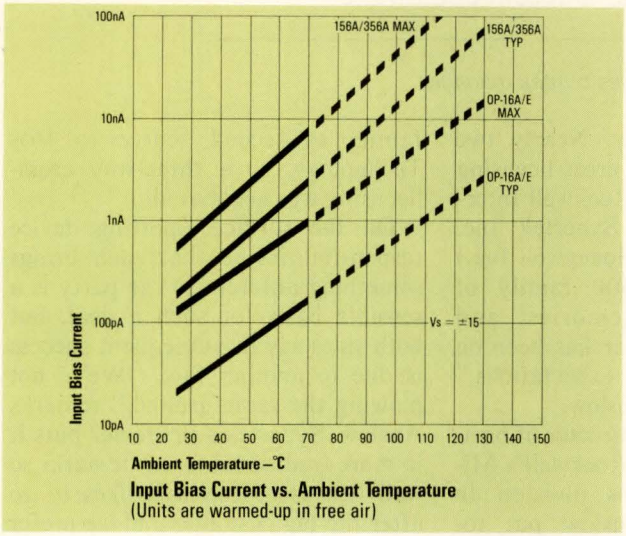

Input Bias Current vs. Ambient Temperature
(Units are warmed-up in free air)

Can products speak for themselves?

In Lewis Carroll's version of Wonderland everything from flowers to playing cards could talk, as long as Alice was there to listen.

In Linear Wonderland, we think PMI's bi-FET op amps also can speak for themselves—as long as there are engineers to listen. Are you listening?

OP-15 studied the spec sheet and frowned. "Those figures look so dull," he said. "Will anyone notice that my supply current is low like the 355's, even though my speed is equal to that of the 356?"

"Sure, they'll notice," OP-16 reassured him. "Remember, most engineers are brighter than they look. That's why they're sure to pick out the fact that I'm twice as fast as the 356, even though I have the same moderate power dissipation. I'm the best power/speed compromise they can find anywhere, obviously."

"If it's obvious, then why bother to say it?" scolded OP-17. "I certainly don't have to tell anyone my ultra-high speed makes me faster than either of you. But I wonder if they'll realize that I'm fast enough to challenge dielectrically-isolated devices."

"You've never been noted for modesty," countered OP-15. "Why don't you tell them yourself?"

"I think I just did," said OP-17, grinning like a Cheshire cat.

Are you getting what you pay for? Or vice versa?

Price comparisons may be meaningless in Linear Wonderland, since no one else is delivering "A" grade bi-FET op amps, at least not with specifications even close to those of OP-15/16/17. But we'll make some meaningless comparisons anyway.

Our bi-FET op amps cost more than 741s—but they're supposed to because they have a larger chip area and an extra ion-implant step. These are two of the factors which make them precision, high speed, low-bias-current op amps providing high performance and speed over the full operating temperature range.

On the other hand, they cost less than LF-355/6/7A's—even though they outperform them.

MODEL	GRADE	Vos	100 PC. PRICE
OP-15/16/17	EJ	0.5 mV Max.	$10.00
OP-15/16/17	FJ	1.0 mV Max.	$ 3.50
OP-15/16/17	GJ	3.0 mV Max.	$ 2.50
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Companies

Rockwell-Synertek deal is blissful

Key to cooperation on 6500 microprocessors and n-MOS process is that the companies sell to different customers

by Larry Waller, Los Angeles bureau manager

Marriages made in heaven seldom include second-sourcing and cross-licensing matches between semiconductor companies. Despite their rosy outlook when announced and later statements that all is going well, veterans of such unions know better.

"They don't work," bluntly says one, "because we compete too hard against each other to be good partners." Most start as liaisons of convenience and soon break up in the scuffle for customers.

So when such an agreement thrives, with each party heaping praise on the other, it catches the eye of a cynical industry. Nearly two years old now, the cross-licensing relationship between Rockwell International Corp. and Synertek Inc. (which is owned by Honeywell Inc.) encompasses the 6500 family of microprocessors, memories, and peripherals and "so far has been on the high end of our expectations," observes Robert E. Anslow.

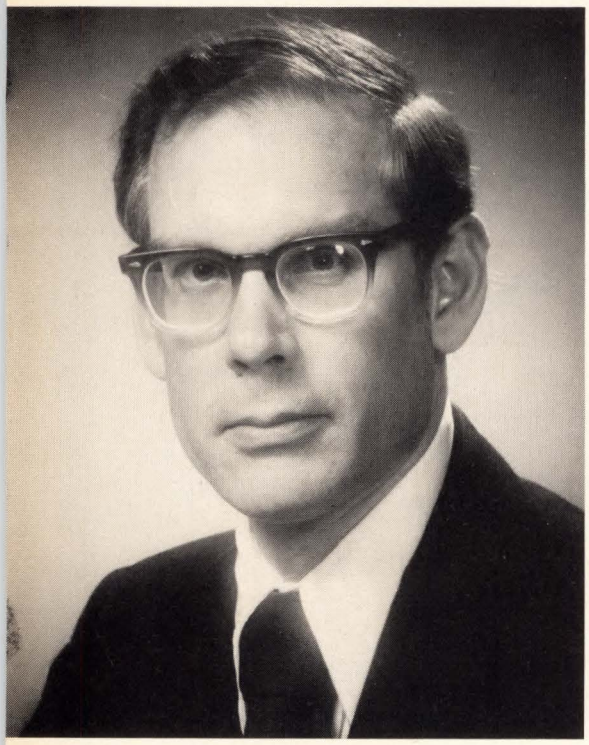
Made the deal. As director of business development at Rockwell's Microelectronic Devices division in Anaheim, Calif., Anslow put together the deal in early 1977. It was a key part of his division's move to acquire an n-channel metal-oxide-semiconductor memory process. The bait was Rockwell's second-sourcing of MOS Technology's 6500 processor. Though Rockwell felt itself well up to speed in building and marketing the processors themselves, acquisition of an n-channel memory process seemed to make more sense than starting from scratch.

Since specialty house Synertek already had staked out a reputation as memory supplier to the four companies that put up the money to start it—General Automation Inc., AT&T, Bulova Watch Co., and Victor Comptometer Co.—it was a natural target. And the market potential was

The attraction for Santa Clara, Calif.–based Synertek was Rockwell's availability, explains president Robert J. Schreiner. "There were only a few other companies large enough to credibly support the 6502 central processor but that had no other n-MOS microprocessors." Rockwell was eager, whereas the others preferred to think about it. Also, Synertek judged itself too small to support an entire device family as second source to MOS Technology, so a three-way cross-licensing was negotiated.

On the surface, splitting device responsibilities so that each brings something different to the party is a sensible basis for such a deal, but both sides say its subsequent success is due to another fact. "We're not plowing the same ground," remarks Anslow. Synertek's Schreiner puts it in more traditional terms: it works so well because "Rockwell likes to go after the big customer and we prefer to make inroads with the smaller ones. Therefore, we almost never get

Negotiator. Rockwell's Anslow handled deal with Synertek that brought n-MOS memory to his company in exchange for 6500.



Noninterference. Synertek's Schreiner says the two companies get along well because they stay out of one another's way.

in each other's way."

Since this is the reef on which most semiconductor deals founder, the usual head-butting confrontations have been avoided. Original developer MOS Technology has made things easier, too, since it has increasingly let the two California firms take the lead with the 6500. And in 6500 R&D, the two stear clear of each other simply by pursuing their own product interests.

All the same, a less tangible factor than hardheaded marketing considerations has been important in making the match work: executives from both firms seem to like and trust each other. Says Anslow, "We both like the candor and honesty of the other." While this might be commonplace in some fields, the semiconductor business is noted for volatile personalities that often clash.

Fruitful. Rockwell, in particular, appreciates the even keel of the Synertek agreement after its abortive 1975 reciprocal second-sourcing deal with National Semiconductor Corp. This earlier attempt to enter the n-channel business came to nought, after being announced with much hoopla, because in practice neither party had much to offer the other without giving away some competitive advantage or other.

Also working in their favor is the sales momentum that the 6500 family, now numbering nearly 30 parts, seems to be generating. "As opposed to the 8080 device, for example, it is still not a mature part, so there is no limit to new design-ins," says Richard Anderson, Rockwell R6500 product manager. As principal link between the firms, he has an overview of all facets of the agreement.

Backing up Rockwell-Synertek statements about penetration of the 6500 into the market are conclusions from Dataquest Inc. of Menlo Park, Calif., an independent research firm. For the first six months of 1978, Dataquest says, the 6500 has a 10% lead in shipments over second-place 8080 devices.

Two-way. While Anderson says that the flow of n-channel technology went one way—into Rockwell—during the first round in early 1977, both firms are up to speed so it "goes in both directions now." Either can produce any of the separate parts, but goes its own way depending on interest. Generally, this shakes down to data-processing customers for Synertek, with Rockwell zeroing in on controller applications. However, Synertek is still heavy on the memory side, principally the 2114 4,096-bit chip.

Another difference between the Rockwell-Synertek accord and others, is that, in Anderson's view, "it's a living document, not a dead end." In practice, this means it contains provisions for adding products to the existing family and maintaining cross-licensing rights. Among the most recent: a cathode-ray-tube controller from Rockwell and 16-K random-access memory by Synertek.

Face-to-face meetings for product review take place regularly, though not called for in the contract, Anderson notes. Another example of cooperation is their sharing of Rockwell's microprocessor development system, System 65. "That's an area Rockwell excels in," says Schreiner. "It makes no sense for a company our size to develop our own MDS."

A ticklish subject for any companies that cooperate concerns U. S. antitrust laws, which are strict about possible restraint of trade. Here, both sides take pains to emphasize the limits of sharing: "We don't talk customers, carving up the market, or price," says Anslow.

No fairy tale. Although the two firms currently bask in a honeymoon glow of successful mutual enterprise, they do not delude themselves that it can last happily ever after. The threat of more head-to-head selling always lurks offstage, Anslow and Schreiner concede, with one example already foreshadowing what could happen. This occurred with the electronic games manufacturer, Atari Inc., which uses so many 6502 services that it was inevitable both would come knocking at its door.

Until now, the disparate sizes of the two firms have also kept their ambitions at different levels, with Synertek doing about $25 million annually, only about a third of Rockwell's gross. But earlier this year Synertek was acquired by Honeywell Inc., which is financing fast growth. If this spurs interest "in a customer base like Rockwell's, things could get sticky," admits Schreiner. □

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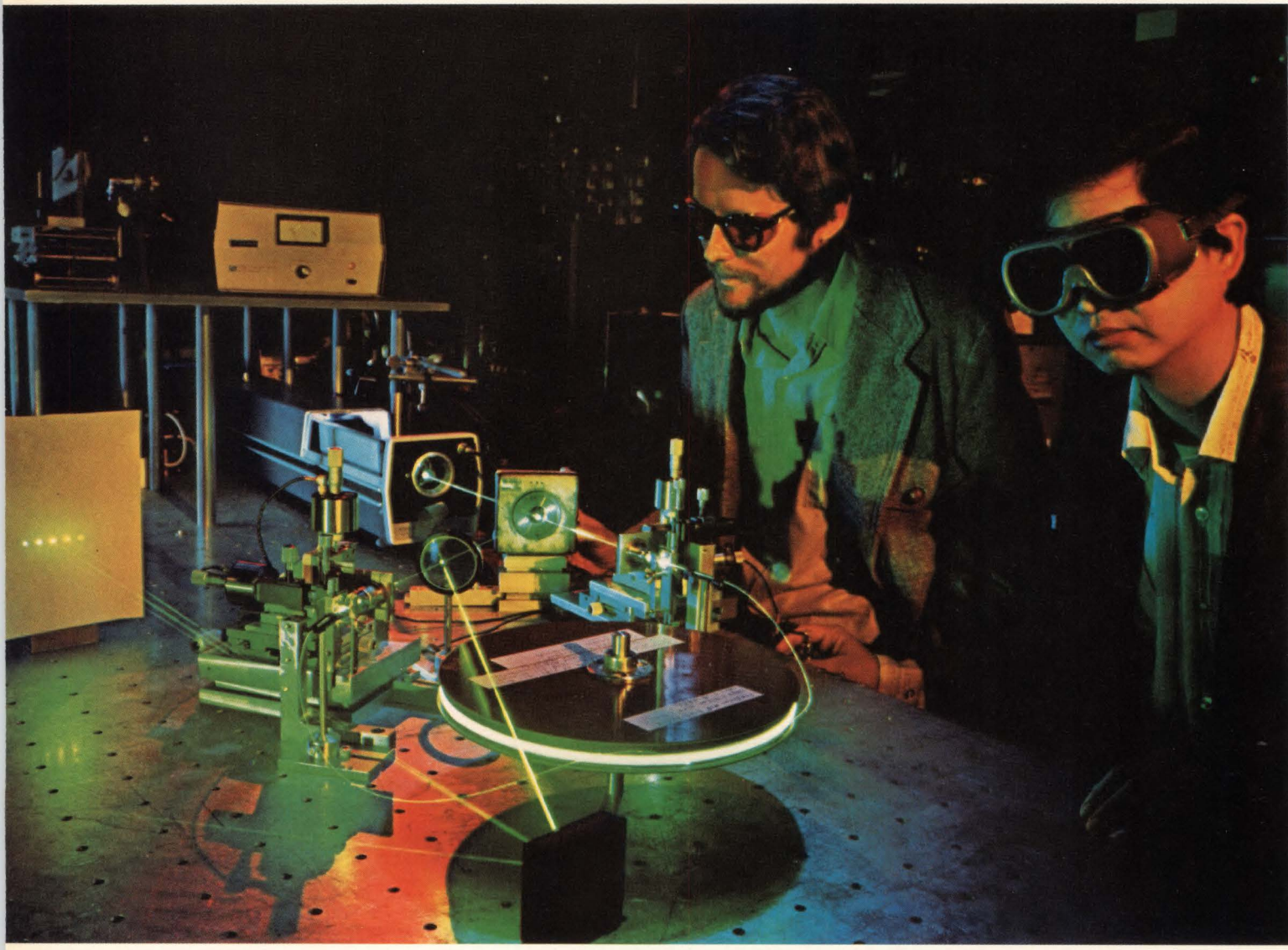

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Bell Labs scientists Roger Stolen and Chinlon Lin work with a fiber Raman laser, one of a new class of light sources that use optical fibers—up to a kilometer long—to produce tunable laser light. At left, the laser's output—which contains multiple Raman-shifted wavelengths—is taken off a beam splitter and dispersed by an external grating to show the broad range of wavelengths that can be tuned.

Bell Labs has developed some of the world's most transparent glass fibers to *carry* light for communications. We've also devised a way to make these highly transparent glass fibers *generate* light. In fact, they are the basis for a new class of tunable light sources called fiber Raman lasers. They're among the latest, and by far the longest, of many lasers invented at Bell Labs, beginning in 1957 with the conception of the laser itself.

Since the new fiber lasers work best at wavelengths at which they are most transparent, we can make them very long. The longest active lasing medium ever built, in fact, was a fiber Raman laser over a kilometer in length. Studying the ways light and glass interact over such distances is part of our research in lightwave communications.

In these new light sources, a glass fiber with high transparency and an extremely thin light-guiding region, or core, is excited by a pump laser. The pump light, interacting with the glass, amplifies light at different wavelengths through a phenomenon known as stimulated Raman scattering. This light is fed back into the fiber by a reflecting mirror. If gain exceeds loss, the repetitively amplified light builds up and "lasing" occurs.

Fiber Raman lasers have conversion efficiencies of about 50%, operate in pulsed and continuous wave modes, and are easily tunable over a broad wavelength range in the visible and near infrared regions of the spectrum.

We've used these lasers to measure the properties of fibers and devices for optical communications; and studies of the lasers themselves have revealed a wealth of information on frequency conversion, optical gain, and other phenomena. Such knowledge could lead to a new class of optoelectronic devices made from fibers, and better fibers for communications.

Looking back

These long lasers come from a long line of Bell Labs firsts:

1957: The basic principles of the laser, conceived by Charles Townes, a Bell Labs consultant, and Bell Labs scientist Arthur Schawlow. (They later received the basic laser patent.)

1960: A laser capable of emitting a continuous beam of coherent light—using helium-neon gas; followed in 1962 by the basic visible light helium-neon laser. (More than 200,000 such lasers are now in use worldwide.) Also, a proposal for a semiconductor laser involving injection across a p-n junction to generate coherent light emitted parallel to the junction.

1961: The continuous wave solid-state laser (neodymium-doped calcium tungstate).

1964: The carbon dioxide laser (highest continuous wave power output system known to date); the neodymium-doped yttrium aluminum garnet laser; the continuously operating argon ion laser; the tunable optical parametric oscillator; and the synchronous mode-locking technique, a basic means for generating short and ultrashort pulses.

1967: The continuous wave helium-cadmium laser (utilizing the Penning ionization effect for high efficiency); such lasers are now used in high-speed graphics, biological and medical applications.

1969: The magnetically tunable spin-flip Raman infrared laser, used in high-resolution spectroscopy, and in pollution detection in both the atmosphere and the stratosphere.

1970: Semiconductor heterostructure lasers capable of continuous operation at room temperature.

1971: The distributed feedback laser, a mirror-free laser structure compatible with integrated optics.

1973: The tunable, continuous wave color-center laser.

1974: Optical pulses less than a trillionth of a second long.

1977: Long-life semiconductor lasers for communications. (Such lasers have performed reliably in the Bell System's lightwave communications installation in Chicago.)

Looking ahead

Today, besides our work with tunable fiber Raman lasers, we're using other lasers to unlock new regions of the spectrum in the near infrared (including tunable light sources for communications), the infrared, and the ultraviolet.

We're also looking to extend the tuning range of the free electron laser into the far infrared region—where no convenient sources of tunable radiation exist.

We're working on integrated optics—combinations of lightwave functions on a single chip.

Lasers are helping us understand ultrafast chemical and biological phenomena, such as the initial events in the process of human vision. By shedding new light on chemical reactions, atmospheric impurities, and microscopic defects in solids, lasers are helping us explore materials and processes useful for tomorrow's communications.

Also under investigation is the use of intense laser irradiation in the fabrication of semiconductor devices. The laser light can be used to heat selective areas of the semiconductor and anneal out defects or produce epitaxial crystalline growth. Laser annealing coupled with ion implantation may provide a unique tool for semiconductor processing.

We've played an important part in the discovery and development of the laser—an invention making dramatic improvements in the way our nation lives, works and communicates.

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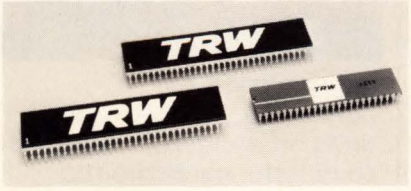

You simply use one of our multiplier/accumulators to multiply a digitized image against a repertoire of anticipated patterns stored in memory. A high degree of correlation results in a numerically high product; a lack of correlation reduces the product value. You set upper and lower thresholds on the accumulated result and you vary the thresholds according to your required degree of flexibility or security.

Because our devices feature on-chip accumulators that store the sum of many previous comparisons, you simply read out the accumulator's contents and compare its value to the numerical thresholds stored inside the CPU. This makes optical character recognition go or no-go—what used to be an extremely complex and costly correlation process is now a piece of cake.

We have 16-, 12- and 8-bit number-crunching chips that grind pairs of numbers together to produce millions of products each second. Our TDC-1010J, for instance, is a 16x16-bit chip that produces a 32-bit product and a 35-bit sum in a mere 115 nsec. (It's designed to operate in a continuous, pipeline mode so the accumulator's operation is transparent—once the first product is generated, it produces more products and adds them to the previous sum.) The TDC-1010J can accumulate products up to 35-bits in length. It accepts data in either unsigned magnitude or two's complement notation. It offers three individual device pins for controlling the chip's three-state outputs, and of course, all its signals are conventional TTL levels. It's packaged in a standard, 64-pin DIP and uses just 3½ watts.

In addition to the 16-bit MAC, our second generation family also includes a new, 12-bit multiplier/accumulator—the TDC-1009J. It operates twice as fast as the original TDC-1003J—just 95 nsec for a complete 24-bit product plus a 27-bit accumulated sum. Like the 16-bit MAC, the TDC-1009J is packaged in a standard, 64-pin DIP. It uses just 2½ watts.

TDC-1008J is the designation of our 8-bit multiplier/accumulator. It generates a 16-bit product and a 19-bit accumulated sum in a snappy 70 nsec, uses only 1.2 watts and is housed in a standard, 48-pin DIP.

For increased flexibility, all our new MACs feature control pins that defeat the accumulators and allow them to operate as conventional, n-by-n-bit multipliers. Even more than that, they all feature on-chip input and output registers; their accumulators have the ability to subtract as well as add; they provide a useful pre-load function that lets you set the accumulator contents to any value and they all run on +5 volts only. All our multiplier/accumulators are radiation hard.

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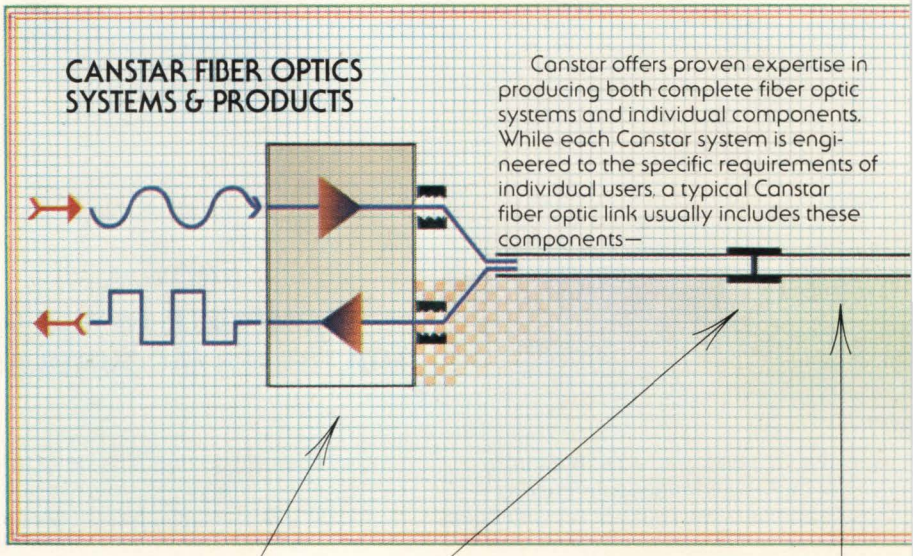

Telecommunications

A telephone company uses a 50km fiber optic system from Canstar to create one of the world's longest high-capacity transmission links. This direct-burial installation, follows a field test, which used conventional plow-in techniques and proved the strength and crush-resistance of Canstar fiber optic cable. The field test also proved that our systems can endure extreme temperature ranges.

Another Canstar telephone application involves a broad-band distribution facility using fiber optics. The system integrates TV and other services with normal telephone service to homes in a rural community.

Transportation

An international airport is using a Canstar fiber optic link to carry radar signals from a remote radar receiver to a computerized control center. The fiber optic cable is immune to electromagnetic and radio signal interference. Its small size, along with the much greater information-carrying capacity of fiber optics, means that upgrades of communications systems can be achieved more easily and economically. Airports, railroads and urban traffic control systems can all benefit from Canstar fiber optics—now!

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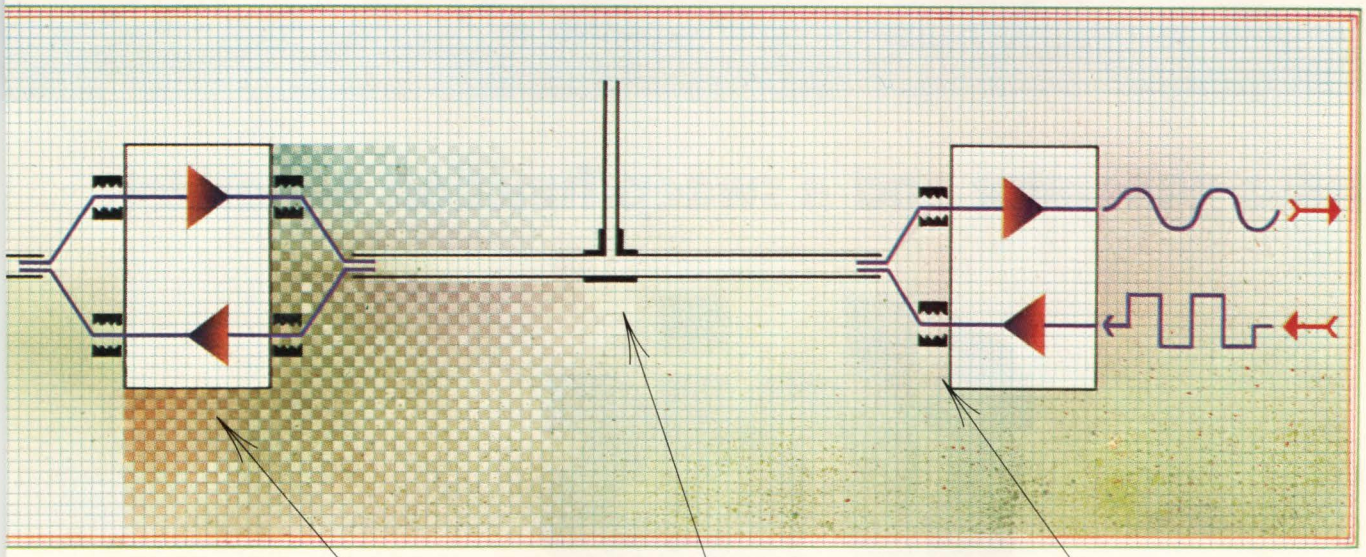

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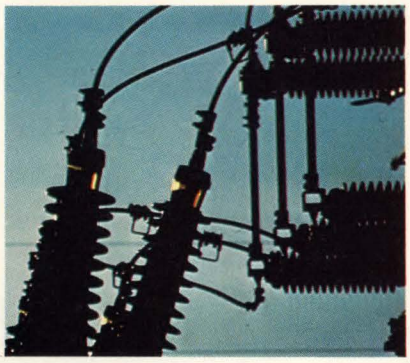
The world's first operational fiber optic CATV supertrunk using digital transmission employs Canstar's technology and products. Five cable TV companies are using Canstar fiber optic cable for the simultaneous transmission of 15 TV and 12 stereo FM channels. This system contains pole-mounted, in-duct and buried sections. It will initially serve a large metropolitan area and can be expanded to serve rural communities that are beyond the range of existing analog systems.



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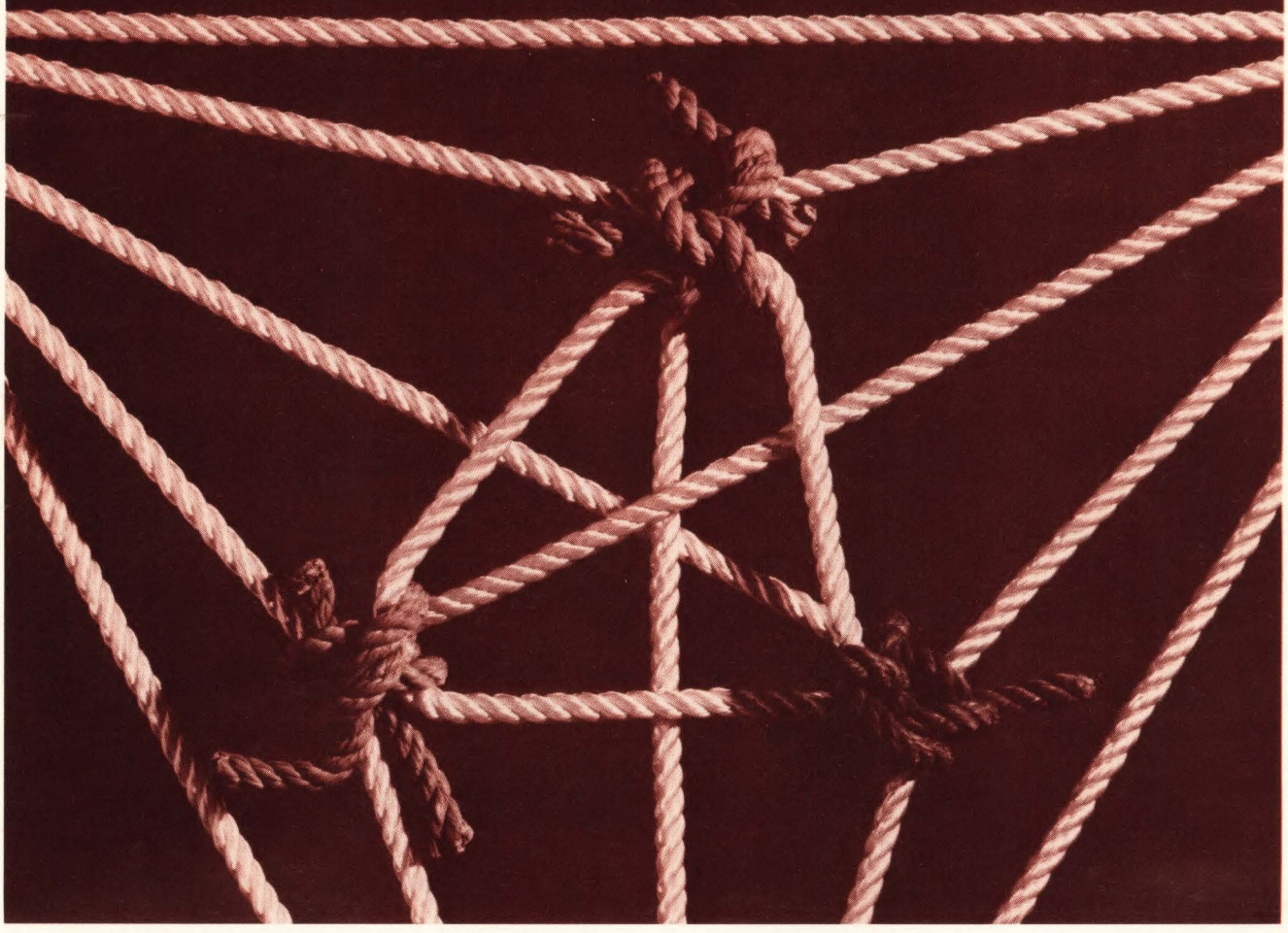
SPECIAL REPORT
New networks tie down distributed processing concepts



by Anthony Durniak, *Computers Editor*

☐ After several years on the theoretical drawing board, distributed data processing is finally taking shape as a commercial reality. Price and performance improvements in computer and data-communications hardware are fleshing the concept out with marketable products. Even the software is becoming more powerful and easier to use, though still lagging in sophistication.

At last a state of the art exists—an art that promises to shape the future of both communications technology and computer architecture. Not a technology in itself, distributed processing instead ties together a number of technologies—computer networking, data-base management, and higher-level programming languages, to name just a few—into more flexible, reliable, and economic computer systems that should soon become a multibillion dollar market.

Despite a variety of approaches and definitions, distributed processing involves one thing: taking computer power out of a single, large, environmentally controlled center and distributing it to wherever the raw information is generated and most of the calculations are needed. But it differs from other decentralized computing approaches in that the geographically dispersed computers communicate with each other over a network and share resources such as software, data stored on disk drives, and printers and other peripherals.

Focusing attention on the concept is the recent change of heart by International Business Machines Corp.,

Armonk, N. Y. Having for years limited the implementation of its Systems Network Architecture with the 3790, its first so-called distributed processing unit, IBM has now announced the 8100 (Fig. 1) and with it its intention of aggressively pursuing the technique [*Electronics*, Oct. 26, p. 88]. Not only does the new unit have stand-alone programming and processing features unavailable on the 3790, but it also can operate in peer networks of other 8100s without a System/370 mainframe as host.

What IBM's interest means

Even more important, IBM's increased interest should clear up much of the present confusion in the marketplace. "Until now the entire burden of defining and selling the distributed data-processing concept has fallen to the independents as IBM has tended to denigrate it. But now everybody has something to target and position themselves against," observes Charles T. Casale, vice president of Bache Halsey Stuart Shields Inc. and a member of its Boston-based technology research group.

IBM's 8100 is only one of many distributed processing products unveiled in the past year or so, during which time the number of announcements of distributed network architectures also has doubled. The new products "are much more appropriate for distributed processing in terms of price and capability than anything preceding them," says Norman S. Zimbel, a researcher with Arthur D. Little Inc., Cambridge, Mass. Also, "more and more [complete] networks are being installed—now you can kick the tires and see that distributed processing is real," adds Maxim Bohlmann, marketing manager for the Autonet architecture of General Automation, Anaheim, Calif.

This popularity indicates more than technological maturity. "There have also been social changes that encourage distributed processing," says Robert Arsenault, manager of communications software planning at Honeywell Information Systems Inc. in Waltham, Mass. Company management styles have become more flexible and decentralized, and "people are more accustomed to making choices and are more reluctant to accept a single solution," he says.

Mirroring the trend to greater divisional autonomy and matrix management schemes, distributed processing lets divisions, manufacturing plants, and warehouses manage their affairs and maintain their own records on a local computer, while giving corporate headquarters access to that data to prepare reports and monitor operations (Fig. 2).

The option appeals to users the more because it is so cost-effective. On-the-spot computing reduces communications costs. Expanding the system by adding small and relatively inexpensive units has to be more economical than upgrading to the next-largest mainframe. Reliability is also improved—one unit's failure does not shut down the entire system, which in some cases is even designed to absorb the workload of the inoperative unit.

"Technology is to distributed processing as fluoride is to toothpaste," comments Michael Weinstein, distributed systems product manager at Digital Equipment Corp., Maynard, Mass. "The technologist likes to talk about networking the way the dentist likes to talk about fluoride. The end user doesn't care—he just wants something that works more cost-effectively."

In growing demand

As a result, the demand for complete networks alone should reach $5 billion by 1983, up from a mere $400 million today, estimates Arthur D. Little's Zimbel in his newly published study, "Networks for Distributed Systems: Status and Prospects." And although that will be some 10% of the entire 1983 computer market, he sees that as only the beginning.

Harold E. O'Kelley, chairman and president of Datapoint Corp., San Antonio, Texas, puts it all in a wider perspective. According to him, distributed processing is by now moving into the second of the three phases of any new concept: "In the first phase, there are a few innovators in the market and some users experimenting. In the second, the concept has been accepted; it is embraced in products and more companies enter the field, heating up the competition. The market matures in the third phase, with shipment growth slowing and with competition shaking out."

1. Important convert. IBM's new 8100 machines boost the distributed processing concept by offering more stand-alone computing power than earlier non-host processors in the Systems Network Architecture. Now 8100s can be used with no mainframes.

PART I: WHY NOW?

The decentralization of data-processing equipment and work is not new—in fact, many trace it back to the first use of keypunch machines to prepare input data away from the actual computer. The concept evolved as terminal products and minicomputers were invented, allowing remote access to the computer or the remote location of a small computer itself.

The key to the recent maturation of the distributed processing concept, however, is the concurrent evolution

of technologies to the point where together they can implement sophisticated but previously impossible or uneconomic functions. Because of this, even terminal manufacturers can afford to smarten up their products enough to compete in the new market alongside IBM and other leading makers of mainframes and minicomputers.

In fact, to differentiate themselves from each other, the hardware manufacturers are having to deemphasize the merits of their hardware and instead promote their architectures for complete distributed processing networks. That means the terminology involved needs disentangling before comparative descriptions of the status of their various systems can be given (Parts 2 and 3).

Growing competence

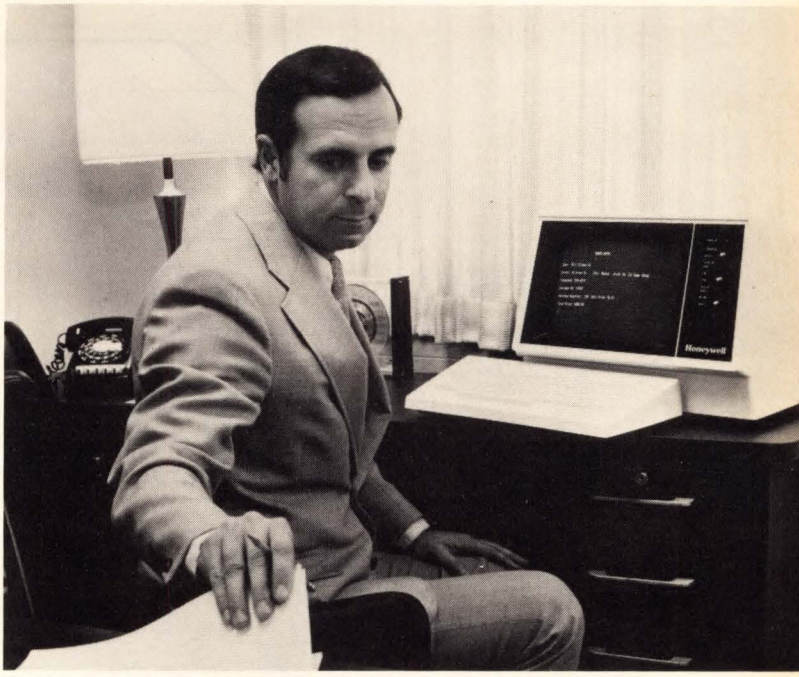
The most important of the technological developments back of distributed processing are, of course, the improvements in large-scale integrated circuits. Microprocessors and memories in particular have slashed the price of computer equipment. Chuck Stein, DEC's manager of distributed systems, points out that the processing power of a PDP-1 that sold for $150,000 in 1965 can today be had in an LSI-11 microcomputer selling for $700. And where 1-megabyte of main memory was almost unheard of in the big computers of the early 1960s, Hewlett-Packard today packages that much memory into the pedestal of its new Amigo-300 small business system, at a price of $32,000.

At the same time that the computers were becoming cheaper and more powerful, so were peripherals. Where 100 megabytes was the standard big computer disk drive a decade ago, as much as 170 megabytes are available in Winchester technology drives packaged for minicomputer systems. In addition, today's 8-inch double-sided, double-density floppy disks can store over a megabyte of data.

According to Wayne Grabyan, director of product marketing for Four-Phase Systems Inc., Cupertino, Calif., this "rapid decline in the cost of the hardware components has enabled companies to offer marketable products in a price range that the user can justify. Distributed processing is price-sensitive, much the way the demand for automobiles is. If cars were $2,000 each, I might have three instead of just two."

Computer software has also become more sophisticated—although not at the same pace as the hardware. File management techniques have been perfected and virtual memory schemes developed that free the user from the restrictions once imposed by main memory limitations. Operating systems have taken on functions and become versatile enough to handle concurrent tasks. Communications software, especially network management programs, have also improved. The new network software from Tandem Computers Inc., for example, has an automatic routing capability that chooses the shortest path between two points and goes to the next fastest link if the preferred route is inoperative or busy.

While the computer industry has continually offered more capability at lower price, the communications industry has supplied a combination of good and bad news. On the good side, its technology has advanced to provide conditioned leased lines that can transmit digital data at rates as fast as 56 kilobits per second and modems that allow speeds up to 9,600 b/s over dial-up voice-grade lines. But as DEC's Stein notes, "the communications costs have been falling more slowly than computer hardware costs—the monopoly situation is holding its prices up."



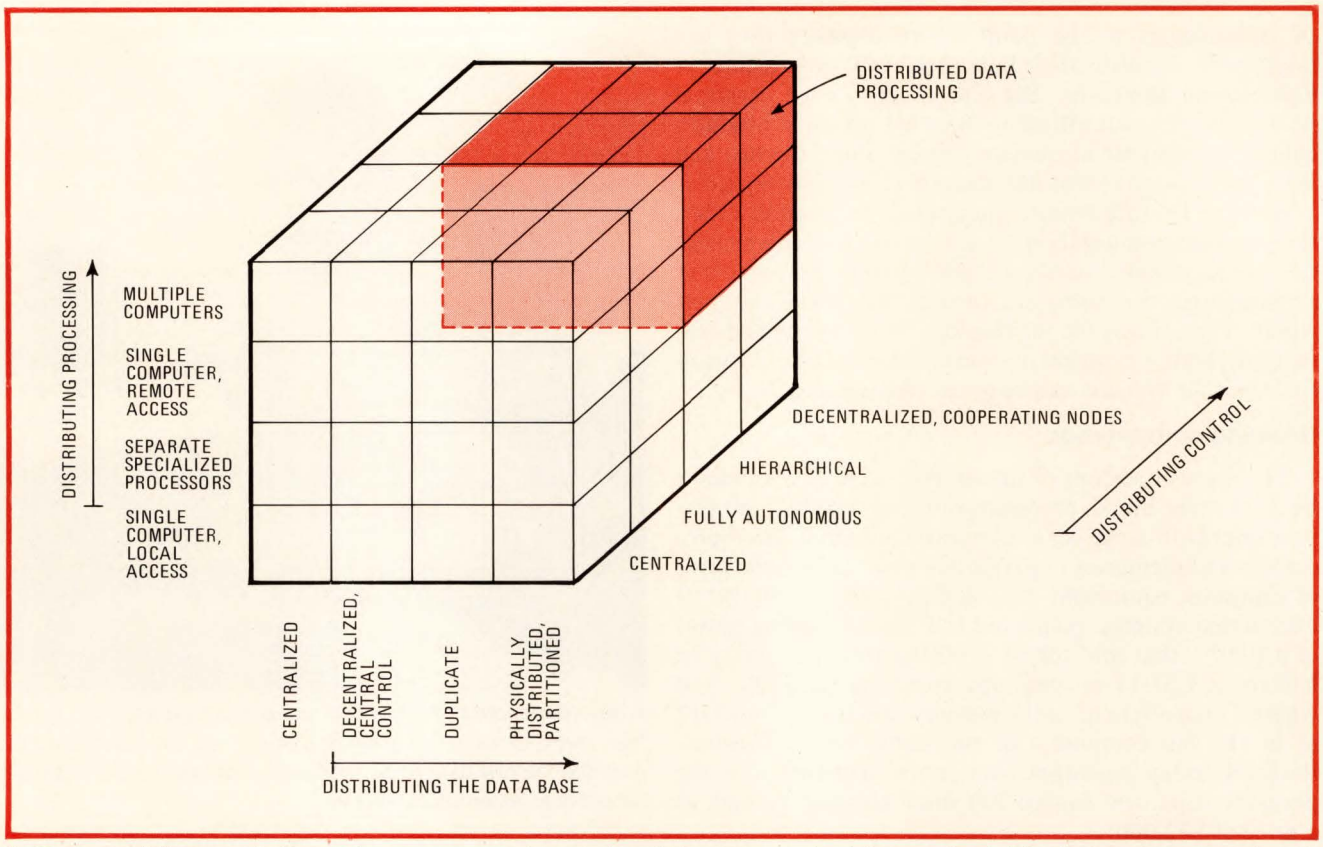
2. Interdependent users. Impetus for distributed processing comes from users' desire to site computing power near the operations that generate the raw data to be processed. Yet headquarters can still access data on the local computer.

These concurrent trends overlap in distributed processing. The increasingly powerful but inexpensive hardware makes it economically appealing to place a computer at the remote site rather than have a terminal transmit the raw data over expensive communications lines to some central computer for handling.

The starting point

This is the reverse of the early situation in distributed processing. Then there were very clear limitations on the power of the remote site, and hence clear differentiation between the companies supplying the equipment. Mainframe computer companies allowed remote access to the computer through communications terminals, very often attached to a remote cluster or communications controller. Terminal vendors produced intelligent terminal systems that performed functions such as key-to-disk data entry, with the local disk holding formatted data for batch transmission or remote-job entry. Minicomputer companies put complete minicomputer systems at the remote site. Although these offered more power than the other approaches, they usually lacked communications.

As the power of the microprocessor and minicomputer have increased, however, they have allowed data-processing functions traditionally considered central also to be handled remotely. One piece of remote hardware could now perform diverse functions, blurring the distinction between the various types of equipment;



3. Conceptual framework. Processing power, network control, and data base can be fully centralized, fully distributed, or somewhere in between. The boundaries of the shaded volume draw the line between true distributed processing systems and the rest.

therefore, with the hardware appearing increasingly similar, the various contenders in the distributed processing marketplace are turning to their communications architectures and distributed processing software to differentiate their products. But a framework is needed to permit a comparison of the various approaches.

A comparative framework

As already mentioned, all distributed processing concepts involve some sort of networking and the distribution of three things—the computer hardware and processing power itself, the data base, and the control over the network. The degree to which these various items are distributed separates the approaches.

For the computer hardware a number of choices are available (Fig. 3). Of course a single computer system with only local access is the oldest available option. Some processing power can be distributed to local specialized machines, such as array processors, input/output channel processors, or front-end communications processors. Single computers can also allow remote access, primarily through intelligent terminals, remote job-entry terminals, or the newer multiple-function terminal systems. At the most distributed extreme are multiple general-purpose computers.

Similar choices are offered for the data base. It can be entirely centralized or decentralized with access to it controlled from a central point. Remote sites may have their own data bases with duplicates residing at some central point, or the data base may be physically distributed and logically partitioned among the network's members, with access to it controlled by the network.

Whether a computer system is a single unit or a complex network, messages within it have to be routed, have their flow balanced between the available paths, and be monitored for errors and other problems. This control can be consolidated in one location, or in the case of unattached multiple computers, all could operate autonomously. Once the multiple units are communicating, two choices are offered for control: it can be hierarchical, residing in one master unit with various tasks delegated to the slaves; or it can be totally decentralized with the various nodes cooperating under a set of rules.

For the purposes of this discussion, it is convenient to define distributed processing systems as those that combine these attributes at a certain level of sophistication. Figure 3 outlines the volume that includes the most distributed of these choices—that is, remote access to single computers or multiple computers, all but centralized data bases, and systems with either hierarchical or decentralized network control.

Implicit in this definition are capabilities unique to the distributed processing concept. From the processing standpoint, an applications program may be allowed to interact with a program running on another computer—that is, it may be able to start or stop the remote program, or take results from it and incorporate them into its own job. In addition to sharing the data base, some approaches also allow other resources, such as printers or communications lines, to be shared.

The medium, as it were, for performing any of this distributed processing is computer networking. Although

some approaches rely on one network topology such as a ring or a star for their interconnections, most network architectures today are flexible, supporting a variety of configurations. One test of an architecture's sophistication, then, is the ability to handle complex topologies with automatic routing and reconfiguration capabilities.

PART 2: THE U.S. SCENE

There are 14 distributed processing network architectures on the market today from U. S. manufacturers, more than half of which were announced in the past 14 months. And that's not to include what is being done abroad (see Part 3, p. 121).

Most of the U. S. companies have similar aims—to distribute processing power throughout their networks and to support the program-to-program communications and data-base sharing unique to distributed processing. But as the chart (pp. 114–5) indicates, what is currently available from the vendors does not yet live up to all their promises—as they are often the first to admit.

The IBM impetus

IBM's Systems Network Architecture, unveiled in September 1974, claimed to be one of the first distributed network architectures but at that time was so severely limited in implementation as hardly to deserve the name. It used only a single host System/370 mainframe and a hierarchy of terminals. The addition of the Advanced Communications Function in November 1976 let more than one host be interconnected, but it is the new 8100 system that has significantly enhanced SNA's distributed processing abilities.

For the first time the remote station in an SNA network can be used to develop and compile programs, as well as execute them. For the first time, too, the network need not be hierarchical; an 8100 can be connected to other 8100s to form a peer network without a 370 mainframe as host.

Edward H. Sussenguth, director of communications architecture and planning for IBM's Systems Communications division, says: "The 8100 doesn't redirect SNA—it's where we were going, and there will be more improvements to come. One reason we started SNA was to be able to run application programs at the terminals, but we needed the basic framework or architecture first. The 8100 is not the only way of implementing our architecture, but it is the most appropriate implementation for our business plan."

A host (non-peer) SNA node must be a 370 mainframe with a 3705 communications controller attached. The 370 runs the DOS/VS, OS/VS1, OS/VS2 SVS or OS/VS2 MVS operating systems with the Advanced Communications Function plus either the Virtual Telecommunications or Telecommunications Access Methods. The 3705 uses the Advanced Communications Function version of the Network Control Programs with Virtual Storage software (Fig. 4). Each host has a "domain" for which it is responsible. This domain consists of subareas defined as either the host computer or extra communications controllers. The 16-bit SNA address is divided into two parts, one designating the subarea and the other the specific terminal device. With such a 16-bit address, up to 64,000 addresses are possible, but IBM says that under SNA today, only 256 subareas are permitted.

The terminal devices previously available for connection in an SNA network to the host 370 were very limited in their functions. As already mentioned, even the most powerful unit, the 3790 communications system, could not do stand-alone data processing. The new 8100 changes the situation radically. When attached to a host 370 that has additional Distributed Systems Executive software, the 8100, with its Distributed Processing Programming Executive operating system, can maintain a local data base as well as do programming. At the same time, the host 370 can access the 8100's data base, keep libraries of programs written for the 8100, and tell the 8100s when to perform those jobs.

An interesting alternative for users is a network of all 8100s. Here IBM says each 8100 is a peer of the other and application tasks on one processor can be activated by a program in another connected 8100 processor. Also data can be read on line from or written on line into a data file located at another interconnected processor.

Despite the availability of this all-peer network, however, the standard SNA network will include host 370s and have hierarchical control. "Fundamentally the network control in today's SNA resides in the host," says Sussenguth. As Fig. 4 also shows, the host in a given domain must initiate and terminate what is called a session between any two subareas, whether in the same or another domain.

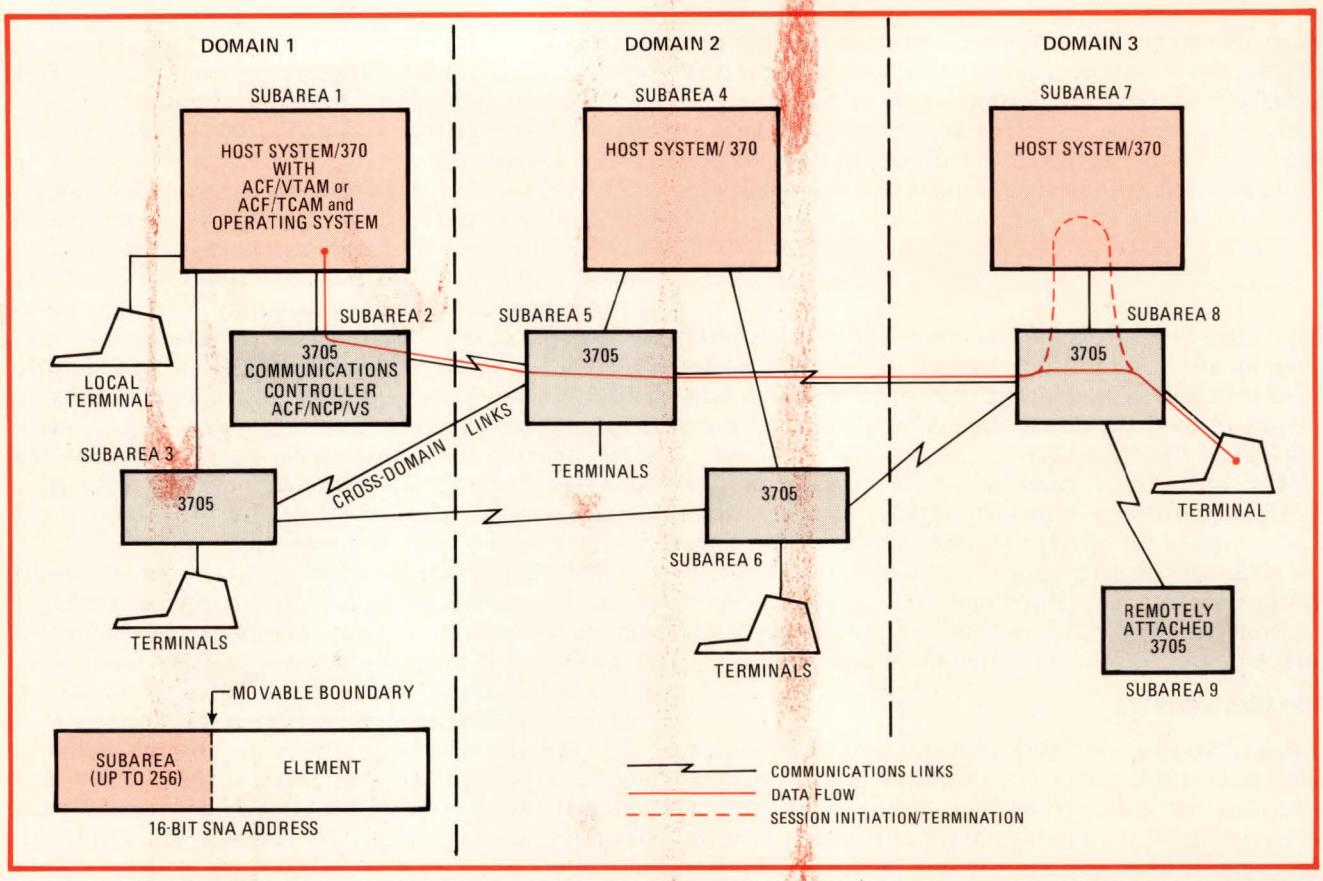
As for other SNA features, the capacity for communication of the hosts' application programs is supported by the Network Job Entry Facility, and resource sharing is allowed under the Advanced Communications Function. Although distribution of the data base is permitted, remote access is currently allowed only to those data bases residing at host computers.

Communications under SNA relies on IBM's Synchronous Data Link Control and, according to Sussenguth, uses packet-switching techniques. SNA also allows the older binary-synchronous-type terminals to be connected. Currently supported are leased and dial-up lines at communications speeds up to 56 kilobits per second.

Following suit

Once IBM had formalized even a restricted network approach, the other five mainframe makers began to follow suit. Each has its own twist, but all say they offer more decentralized control of the network than IBM. Some have chosen to use the architecture as the vehicle for defining all of their distributed processing capabilities, whereas others limit the architecture solely to providing the necessary communications for a distributed processing system.

The most recent is Burroughs' Network Architecture [*Electronics*, Oct. 12, p. 42]. To be used with the B1000 through B7000 mainframe computers, BNA will be implemented with Host Services and Network Services software that will be available at the end of 1979. William R. Brown, BNA product manager, notes that



4. Dominant domains. IBM's Systems Network Architecture is almost always hierarchical: each host/370 initiates and terminates communications sessions between subareas within its domain and across domain boundaries. An SNA address can specify 256 subareas.

BNA borrows many of its features from the Detroit company's Global Memory scheme, which allows up to four central processing units (B6800s) to share a memory.

The Host Services software has six protocols that provide such functions as program-to-program communications, access to a remote data base, and resource sharing. The Network Services software routes and manages the messages. As Fig. 5 shows, this software sets up logical ports that interface to the Host Services protocols on the one side and the host-to-host router on the other. This latter portion of the software routes messages, which use only a logical or symbolic name, to the proper physical location.

The major differences between the Burroughs and IBM approaches are in data-base access and the network control. Where IBM currently limits the amount of data interchange, BNA's Host Services has protocols that permit files to be opened and accessed in the data bases of remote hosts, using the files' logical names. And with BNA, the Network Services Software will automatically reconfigure the network when a host drops out, a feature not available from IBM. But whereas IBM allows terminal clusters to be directly addressed in the SNA network, Burroughs allows terminals to be interfaced only through a host's Message Control System.

Not one, but two network products are available from Minneapolis-based Control Data Corp. In March 1974, CDC introduced its Cyber 170 Network products for connecting its Cyber 170 line of computers, and in May 1976 it unveiled its Distributed Network System, which can interconnect dissimilar computers from other vendors. Although it promises many of the distributed processing advantages, today the Cyber 170 concept is one of the more limited on the market, allowing only a single host per network. CDC's distributed systems product line manager, Keith Lucke, says multiple-host Cyber 170 networks are planned but "it'll be at least a year and a half before we're ready to announce that." DNS, on the other hand, allows multiple hosts to be connected.

With DNS a Cyber 1000 computer is defined as a node and must be used to connect any host to the network. The hosts need not be of the same type, or even from the same vendor, since these Cyber 1000s do the code conversions necessary for data to be exchanged by dissimilar computers. Because the computers are different, however, both communications between application programs and remote data access are limited to the individual operating system's ability to permit them.

A kind of glue

Introduced in January 1977, Honeywell Information Systems Inc.'s approach uses "the Level 6 minicomputer as the glue, if not the common element," says Robert Arsenault, manager of communications software planning for the Waltham, Mass., firm. At present the only mainframes that can be used in the system are Series 60, Level 66s, and they can only be attached to it through a Level-6-based front-end processor (Datanet 6678), whereas Level 6 machines can be attached directly.

Although there is no limit on the number of nodes in such a network, a Honeywell spokesman says a practical limit today would be about 200. Topology is not defined, and network control software, called the Network Processor Supervisor, resides in the front ends.

Like many of his competitors, Arsenault freely admits that DSE lacks some of the capabilities it is expected to have eventually, such as the ability to use all Series 60 mainframes. "DSE contains the architecture, but the actual products will be evolving over the next 10 years."

NCR Corp.'s Distributed Network Architecture is "a communications architecture only," says Robert Galin, director of communications. "The facilities for two processors talking are there, but the protocols for program-to-program communication are not in DNA, nor are distributed data bases implicit in the architecture." The Dayton, Ohio-based company unveiled DNA in July 1977 but is one of the most vague when it comes to defining currently supported capabilities.

Under DNA, control of the network is decentralized. Node processors will handle network control and allow varying topologies; store-and-forward packet-switching techniques will route messages automatically over multiple paths and also reconfigure the routes automatically in the event of a link failure. Such a node processor has not yet been introduced, however, Galin notes. Communications between DNA products, once they are announced, will use the NCR Data Link Control protocol, a bit-oriented protocol that NCR says is similar to the ISO's High-Level Data Link Control.

Still evolving

Like many of its competitors, the Blue Bell, Pa.–based Univac division of Sperry Rand Corp. is defining an architecture that will offer decentralized network management and support many of the more sophisticated distributed processing features. But, says Neil Gorchow, vice president for product strategy and requirements, "it will be evolving over the next several years, and it will be 1981 before there are enough pieces in place to make it meaningful."

The heart of the current implementation of Univac's Distributed Communications Architecture is a dedicated minicomputer—the Distributed Communications Processor. This node processor links mainframes and terminals to the network. Running Univac's Telcon network software, it manages such functions as scheduling, routing, and switching messages and detecting and correcting errors. With the network control thus decentralized, DCA can also support a variety of network topologies. Currently only Univac's 1100 Series of mainframe computers can be attached to a DCA network, but industry observers expect Univac to add its recently acquired V77 line of minicomputers to the list soon.

Although DCA does not specify the rules for gaining access to remote data or for enabling programs to communicate, it will supply a dialog between computers for those activities.

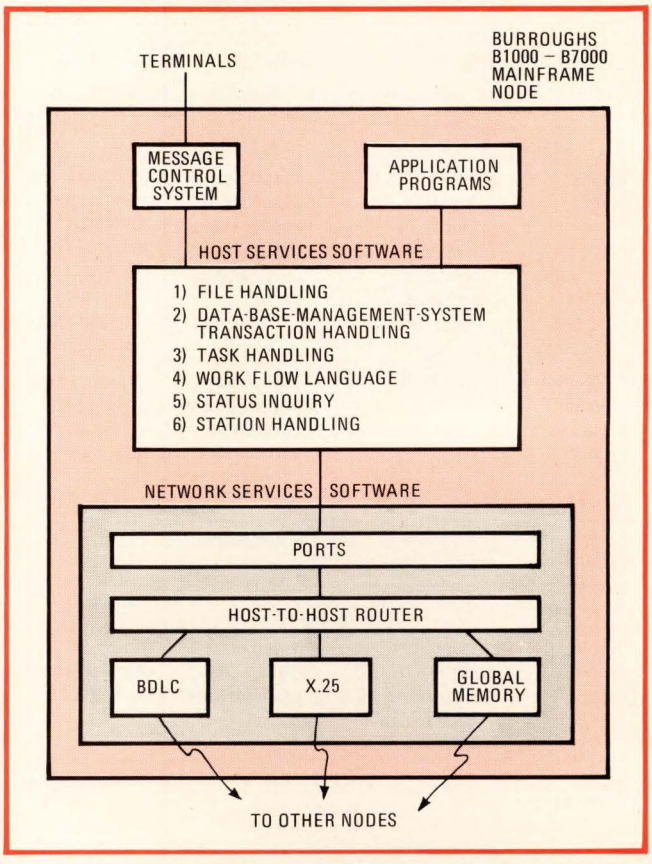
Emulating their big brothers in the computer business, the minicomputer makers have also taken to formulating network architectures. As DEC's Stein says, "If you think about it, we've always been in distributed processing. We built a business by selling small computers that people distributed to remote sites, at a time when everyone was installing central hosts in large, air-conditioned rooms." And without a large installed base of those large mainframe computers to protect, the minicomputer vendors have been much more willing to support more flexible distributed processing features.

Minimakers' architectures

Digital Equipment Corp., Maynard, Mass., pioneered in this area in April 1974 with its DECnet. The name for a collection of software and protocols implementing Digital's Network Architecture, it was plagued by technical and implementation problems. So, after what many in the industry viewed as a false start, the company revised DECnet and reintroduced it last March. As the chart shows, DECnet II currently supports several members of DEC's family of computers.

According to David Loveland, a DEC software product manager, the DECnet philosophy is the same and only the implementation has changed. "For example, Digital's Data Communications Message Protocol [DDCMP] was revised to allow it to carry multiple messages concurrently. This doubles the number of messages transmitted per second," Loveland says.

As shown in Fig. 6, control of the DEC network is handled by the Network Services Protocol, which will route messages between systems, provide program-to-



5. Assorted services. The latest mainframe entry is Burroughs' Network Architecture, which uses Host Services software to support interprogram communications and Network Services software to manage the network and route messages.

NETWORK ARCHITECTURES FROM U.S. MANUFACTURERS

	MAINFRAME COMPUTER VENDORS						
	Burroughs	**Control Data**		**Honeywell**	**IBM**	**NCR**	**Sperry Univac**
Architecture name and introduction date	Burroughs Network Architecture Oct. 1978	Distributed Network Systems May 1976	Cyber 170 Network Products March 1974	Distributed Systems Environment Jan. 1977	Systems Network Architecture Sept. 1974	Distributed Network Architecture Aug. 1977	Distributed Communications Architecture Nov. 1976
Composition of node	B1000 – B7000 mainframes only	Cyber 1000 to interface foreign hosts	255X-Cyber 18-based computer	Series 60, Level 66 with Datanet 6678 front end or Series 60, Level 6	host node must be a System/370 mainframe with ACF VTAM or TCAM and 3705 Communications Controller with ACF/NCP/VS	not yet announced	Distributed Communications Processor with Telecon software
Limit to number of nodes[1]	no limit	256 nodes	only 1 host per system with up to 4 front ends	200	255 subareas	open-ended	255
Other attachable devices	terminals attached only to nodes through network definition language	non-CDC host computer; up to 30,000 terminals per node	each remote node can have up to 254 lines		System/32 System/34,8100 3600 series of equipment, 3270 terminals		currently only 1100 series mainframes
Network control	decentralized	decentralized in Cyber 1000 nodes	centralized in host	decentralized	hierarchical	decentralized	decentralized
Location of data base	decentralized	each host may have a data base	centralized in host	decentralized	centralized	not determined by DNA	decentralized
Access rules[2]	host services software allows files to be remotely created and accessed	if host processor allows remote access DNS will provide path	an application program must be initiated to remotely access data; physical location needed	not supplied by vendor	local bases may be maintained but remote access to these not currently supported		indirect
Program-to-program communications	yes, under host services	supported but must be compatible with addressed host	currently only one host supported with terminals	limited to transaction processing	allowed under Network Job Entry Facility	not determined by DNA	supported, but applications – dependent
Communication protocols	BDLC, X.25 and Global memory	block mode	HDLC	HDLC	SDLC	NCR-DLC	HDLC
Communication links	leased or dial-up to 56 kb/s or local Global Memory links	leased or dial-up lines up to 56 kb/s	leased or dial-up lines up to 56 kb/s	leased or dial-up to 56 kb/s	leased or dial-up to 56 kb/s		leased lines to 56 kb/s
Comments					3705s can also be connected as subareas		

[1] Physical or theoretical maximum; does not account for throughput

[2] Assumes proper security clearance for data access

	MINICOMPUTER VENDORS						MULTIFUNCTION-TERMINAL VENDORS	
	Computer Automation	Digital Equipment	General Automation	Hewlett-Packard	Modular Computer	Tandem Computers	Datapoint	Sycor
	Syfa Virtual Network April 1978	Digital Network Architecture (DECnet) originally April 1974, revised March 1978	Autonet June 1978	Distributed Systems Network Oct. 1977	MaxNet Dec 1974	Guardian/ Expand Oct. 1978	ARC Dec. 1977	Sycorlink Dec. 1977
	Syfa Small Business Systems	PDP-11 with RSX-11S RSX-11M RSX-11D IAS RSTS/11E VAX 11/780 DEC System 10	NDS 460 Computer	HP 1000 or HP 3000 computers or 2026 terminal systems	Classic, ModComp IV, ModComp II	Tandem 16 computers	5500 or 6600 as either file or application processor, 6000 or 3800 as application processor only	Model 405 or 445 processors
	31 per controller; multiple controllers can be inter-connected	250 nodes	255 nodes	no limit	no limit on computers but limited to 6 levels	255	255 with at least one file processor	9
	up to 992 Syfa terminals per controller, IBM/3270/ 3790 units	terminals connected to system node					through a 6010 with DCIO an IBM Syst/360 or 370 can be channel-attached	
	centralized in Virtual Network Controller	Network Services Protocol allows it to be centralized or decentralized	decentralized	decentralized	hierarchical	decentral-ized	decentralized, handled by Resource Inter-face Modules	decentralized
	decentralized	decentralized	decentralized at each node	decentralized at each computer	decentralized	decentral-ized	at dedicated 5500 or 6600 file processors	decentralized
	any user can access any file on any drive in network; location not necessary	any user can create or access files at remote node using Data Access Protocol	remote access allowed; currently loca-tion must be known	remote file and data-base access with/DS 3000 must state physical location	remote file access permitted	uses Enform inquiry language	any application processor can access any file processor, but own files not accessible remotely	remote data-base access allowed
	source or object code may be down-line-loaded to any processor	task-to-task communi-cations supported	asynchronous program-to-program, re-mote program control, down-line loading	allowed even between different operating systems using virtual terminal concept	remote execution and down-line loading	yes	allowed under Multilink portion of Datashare operating system	yes, but inter-mediate disk files needed
	X.25	DDCMP	X.25,SDLC	Bisynch	HDLC	Tandem end-to-end protocol	resembles packet switch	asynchronous or synchronous
	leased or dial-up to 56 kb/s	leased or dial-up to 19.2 kb/s local 5–15,000 ft 56 kb/s 1 Mb/s twisted coaxial	2.5 Mb/s locally leased or dial-up to 56 kb/s	leased or dial-up to 19.2 kb/s locally: 250 kb/s to 1,000 ft or 2.5 Mb/s coaxial cable	leased or dial-up lines to 9,600 b/s local links to 200 kB/s	leased or dial-up line up to 56 kb/s or X.25 networks	coaxial cable at speeds ≈2.5 Mb/s	coaxial cable
		PDP-8 not yet upgraded to Phase II		HP 1000s can only be linked to HP 3000s over coaxial cable up to 2,000 ft long			no single cable longer than 2,000 ft; up to 10 repeaters can extend it to 4 miles	no length of cable over 2,000 ft

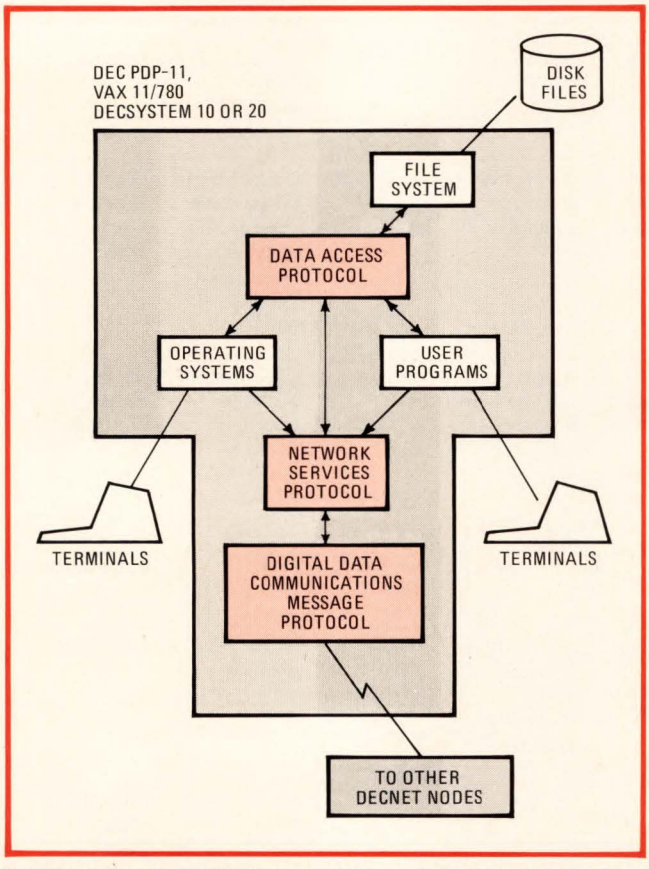
SOURCE: *ELECTRONICS*

program communications, as well as reconfigure the network. Currently, however, Stein notes, the Network Service Protocol supports only point-to-point communications over leased or dial-up lines and cannot handle routing through the system.

DECnet also specifies decentralized data bases with remote access permitted under its Data Access Protocol. DAP provides a universal network input/output language and translates the various computers and operating systems' data requests into this universal language for transmission to other points in the network.

Another early network participant was Modular Computer Corp., Fort Lauderdale, Fla., which introduced Maxnet in December 1974. Although aimed primarily at industrial control and scientific applications, rather than the more general-purpose business applications of its competitors, the Maxnet system has many of the same distributed processing features. Currently available on either Modcomp II, Modcomp IV, or the new Classic computer lines, the Maxnet allows downline loading of tasks and remote activation of tasks on other processors in the network. In addition, data bases are distributed, with access to remote files supported from the various network members.

Although network topologies can vary, network control in a Maxnet system tends to be hierarchical. Under the host, up to five levels of satellite processors can be attached.



6. Mini network. Digital Equipment Corp.'s DECnet architecture has three protocols: the Data Access protocol for input/output, plus the Network Services and Digital Data Communications Message protocols, which together support communications.

Most of the other minicomputer vendors jumped into the fray only in the past several months.

Hewlett-Packard Co., Santa Clara, Calif., replaced its 9700 distributed system computer in October 1977 with its more sophisticated Distributed Systems Network products for its HP 1000 and HP 3000 lines of computers and its 2026 terminal systems. DSN software enhancements are added to every processor in a given network to provide the network control and distributed processing functions. Among these are remote command processing, program-to-program communications, and access to remote data bases or files. Although a specific network topology is not required, the DSN network does not perform automatic routing and reconfiguration. Network control can be centralized or decentralized.

There are differences between networks of HP 1000 and 3000 computers. Because of its business-applications orientation, one composed of HP 3000 systems does not offer pass-through capability. Although this technique makes routing less transparent to the user, it allows business users to keep track of who is using which CPUs. On the scientific and industrial-control-oriented HP 1000 systems, where the need for accounting for every minute of CPU time is presumably less critical, a nodal addressing command handles pass-through routing. Resource sharing under DSN also requires the user to specify to which processor the resource is attached and its logical name.

In networks of the same type of computer, one program can communicate with another. But when the dissimilar HP 1000 with its real-time executive operating system and the HP 3000 with its batch-oriented Multiprogramming Executive operating system are in the same network, the remote command-processing technique is used.

Communications under HP's DSN use leased or dial-up lines at speeds up to 19.2 kilobits per second. System 1000s and 3000s, however, must be connected with coaxial cable, which allows speeds up to 2.5 megabits/s.

A star topology

Computer Automation Inc., Irvine, Calif., added networking capability to its SyFa line of small business systems last April in the form of the SyFa Virtual Network. First delivered in the third quarter of this year, the SyFa virtual network relies on star network topology with what Rick Ramras, special projects manager, calls "a central traffic cop, the Virtual Network Controller." Built around Computer Automation's top-of-the-line LSI 4/90 minicomputer, the controller allows up to 31 SyFa processors to be attached. Although control is centralized, any terminal may serve as the system's console. Using X.25 packet-switching techniques, the controller handles message routing and network management, although it cannot reconfigure the network.

A good example of how new semiconductor technologies subserve the new network architectures is Computer Automation's microprocessor-based Distributed Data Base Processor. It interfaces the SyFa processors to the Network Controller and handles the X.25 communications protocols. Although disk drives are not connected to it directly, it keeps track of which files are maintained

on the SyFa processor to which it is attached and handles all requests for remote access to those files.

Network controllers can also be interconnected, thereby expanding the total SyFa Virtual Network, Ramras notes. The only program communications supported by SyFa, however, is the down-line loading of software.

General Automation Inc., Anaheim, Calif., which has been marketing computer networks to banks for some time now, formalized its network architecture last June with the introduction of its Autonet architecture. Based on the model 440 Network Data Series of minicomputers, first delivered this fall and slated for volume production by next March, the architecture allows up to 255 such nodes to be networked together. Each of those 440 nodes can support up to eight terminal clusters for a total of 32 terminals.

Network topologies are not specified, and network control is distributed throughout the network nodes, says Maxim Bohlmann, Autonet marketing manager. "The network uses packet-switching techniques compatible with X.25, at rates up to 2 megabits per second," he says. Asynchronous program-to-program communications will be supported by Autonet, any processors' operating systems can be remotely controlled, and down-line program loading and remote initialization of programs will also be allowed. Access to files and data bases will eventually be transparent to the user, although currently the user has to know the physical location of the file to route the request properly.

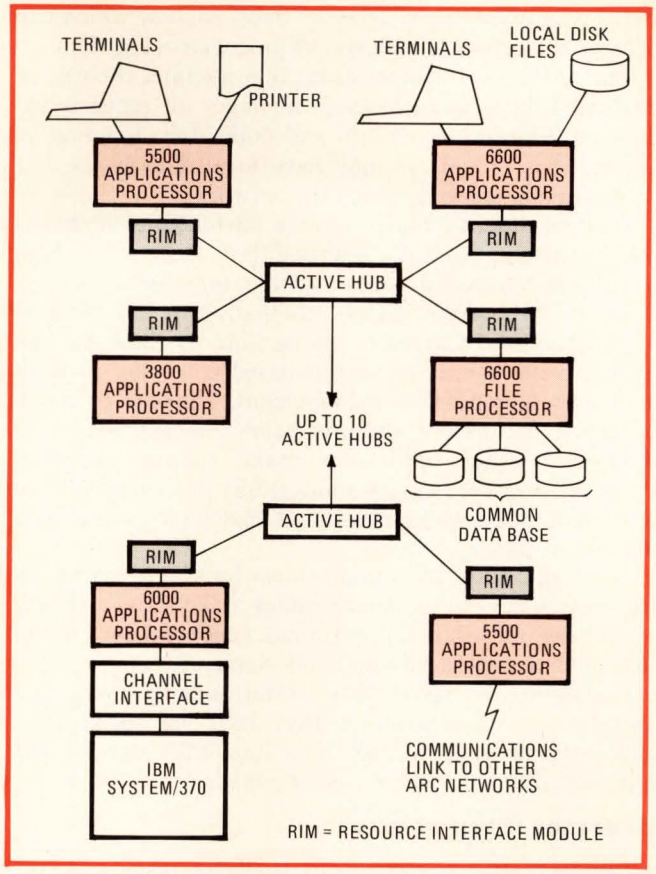
The most recent minicomputer company to enter the network architecture game is Tandem Computers Inc., Cupertino, Calif., which just this October announced its Guardian/Expand software. In many ways, Tandem has been marketing distributed systems ever since it introduced its Tandem 16-Nonstop Computer Systems in December 1975, which allow between two and 16 central processing units to operate in parallel, sharing memory and peripherals. The Guardian/Expand software brings that concept to geographically dispersed networks of up to 255 of the Tandem 16 minicomputers.

The Tandem architecture, slated for first deliveries next March, features one of the most sophisticated of network management systems. Its Network Control Process is decentralized, and automatically picks the fastest link between two points. If that path is busy or inoperative, it reroutes the message to the next fastest. A special algorithm decides between equally fast paths.

Program-to-program communications are already supported by the Guardian operating system used on Tandem-16 processors. For access to distributed data bases, Tandem introduced its Enform language for programming those requests.

Approach from the other end

In addition to the mainframe computer makers and the minicomputer vendors, the third source of distributed processing concepts are the vendors of multifunction terminals. Traditionally these vendors have marketed products classified as intelligent or data-entry or remote inquiry or remote batch terminals. Today many of their products are as powerful as minicomputers and perform a combination of these four functions plus,



7. Strings of stars. Datapoint's Attached Resource Computer System strings star-like arrangements of processors along a coaxial cable network up to four miles long. ARC processors are specialized, performing either applications programs or file management tasks.

in many cases, stand-alone processing.

Attached Resource Computer system, or ARC, is what Datapoint Corp., San Antonio, Texas, calls its distributed data-processing approach. As Vic Poor, senior vice president for research and development explains, ARC relies on two techniques. One is "a software-controlled specialization of the processors into two functional types—one to execute applications and another to manage data-base information." The second is "a combined hardware/software interprocessor bus which handles the whole task of high-speed interchange of information between the two types of processors without imposing an overhead penalty on them."

In addition to its 5500 and 6600 processors, which can adopt either of these two roles, Datapoint offers its 6000 and 3800 Attached Processors, which can perform only as applications processors in an ARC network. Up to 255 processors can be attached to ARC, at least one of which must be a file processor. Connecting each processor to the communications network, or interprocessor bus, is a Resource Interface Module—a microprocessor-based unit that handles the bus's packet-switching protocol, the message routing, and other network management tasks. Coaxial cable interconnects the processors. Since no one piece can be over 2,000 feet long, repeaters called Active Hubs are used to extend the network. Up to 10 hubs can be attached in succession permitting overall lengths up to four miles, Poor notes. The network topology then can

best be described as a string of hubs, each of which can become the center of a cluster of processors (Fig. 7).

The processor (or processors) that assumes the role of dedicated data-base processor manages all requests for data. In addition, the 5500s and 6600s that function as applications processors may have local data bases, but these are not accessible from the network.

Probably the smallest network currently available is Sycor Inc.'s Sycorlink, unveiled last December. Also based on hardwired, coaxial-cable interconnection, it links the Ann Arbor, Mich., company's model 445 and 405 processors. Currently up to nine of these can be linked, using a microprocessor-based controller at each node to handle network management. The data base can be distributed among the processors attached to Sycorlink, and other units can make remote accesses. Program-to-program communications are supported by Sycorlink, but a spokesman notes that intermediate disk files are necessary.

Although all of the mainframers have network architectures, many of the minicomputer makers and virtually all of the multifunction-terminal vendors have yet to take such a structured approach. Some of them say they are studying the possibility of introducing their own architecture. Others admit they have no such plans, choosing, instead, to fall into line with one of the announced architectures—usually IBM's.

Under the IBM umbrella

"By operating under the umbrella of IBM's SNA, we don't waste development resources in going our own direction," says Four-Phase Systems Inc.'s Wayne Grabyan. "And your own direction may be wrong anyway." Four-Phase's direction is a good example of the one many of the multifunction vendors are taking (Fig. 8). It packages a general-purpose minicomputer as a controller of a cluster of terminals, but with powerful software. The Cupertino, Calif., company's Multifunction Executive operating system, for example, lets the same piece of hardware perform word processing and stand-alone Cobol processing concurrently, as well as a terminal's traditional functions like data entry and inquiry. "You'll see more and more multifunction capability coming out of Four-Phase," Grabyan says.

Companies offering their own version of that multifunction approach include Minneapolis-based Data 100, which markets its Series 80 terminal products. Raytheon Corp.'s Data Systems, Norwood, Mass., markets its minicomputer-based PTS-1200 distributed processing system, while Harris Corp.'s Data Communications division in Dallas, Texas, aims its 1600 series of communications terminals at that market. Mohawk Data Sciences Corp., Parsipanny, N. J., introduced the separate Series 21 small business system, while intelligent-terminal maker Inforex Inc., Burlington, Mass., entered the distributed processing field with its System 7000 minicomputer. Nixdorf Computer Corp., the U. S. subsidiary of the German company that acquired Entrex Inc. in April 1977 and is now headquartered in Burlington, Mass., competes with its Entrex 600 Series. Key-to-disk maker Computer Machinery Corp., now the CMC subsidiary of Pertec Computer Corp., Los Angeles, Calif., just this past February unveiled its XL40 Distributed Processing System for this particular market.

Basic Four, the Santa Ana, Calif.–based subsidiary of Management Assistance Inc., has the distinction of being one of the few companies with a Distributed Data Processing division. Company vice president David Seigle, who heads the division, says it will position itself "somewhere between the low-end minicomputer companies and the high-end multifunction terminals." According to division marketing director Al Davis, Basic Four will capitalize on its turnkey approach to selling small business systems that include all necessary software. "Distributed processing goes right down to the clerk using the system at the remote site," says Davis. "Sure, there may be a need for more networking in our product line, but there is also a need for more applications software to use that additional network capability."

An absentee

Conspicuous by its absence from the list of vendors with network architectures is Data General Corp. of Westboro, Mass. Yet Art Lynch, marketing manager for communications products and terminals, says, "Our best environment is the older IBM binary synchronous-compatible one. After all, with IBM having 70% to 80% of the marketplace, it's their customer base that we all reside in." And given the current instability of the distributed processing market and the limited number of SNA installations, Lynch says, it's in the best interests of both his company and the customer to stay with the widely used communications technique. "If a user goes to a vendor's networking scheme, they're locked into that vendor—there is no DECnet-compatible gear on the market, for example."

PART 3: EUROPE AND JAPAN

Although they started later than their American counterparts, European and Japanese computer companies are rapidly joining the distributed processing game. Many of the major foreign computer companies have announced or are readying network architectures with the full distributed processing capabilities featured in American systems. And their efforts to establish packet-switched data-communications networks will foster the use of the approach.

The public arena

No fewer than 13 European postal, telephone and telegraph authorities have proposals pending for developing such networks. For instance:

- France's PTT is scheduled to start its Transpac service by the end of this month. Employing software jointly developed by the French software house Sesa and the British-based Logica, the Transpac network uses the X.25 interface with Sems Mitra minicomputers and Philips CP50 computers as nodes and switches.
- At the same time, the European Economic Community is scheduling startup of its Euronet packet-switching network for the middle of the next year.
- The British Post Office currently has an experimental

8. Under the umbrella. Some vendors without network architectures have chosen instead to operate under the umbrella of IBM's SNA. Four-Phase Systems' clustered terminal units, for example, do stand-alone data processing yet link into a host IBM mainframe.

packet-switched network running between some 33 users, although it is expected to take at least another year of tests before it goes public.

- The Spanish packet-switching network, Red Especial de Transmisión de Datos (RETD), has been in operation since 1971. The Spanish telecommunications authority, the Compañia Telefónica Nacional de España (CTNE), says the network is currently being adapted to interface with the X.25 standard.
- Japan's Nippon Telegraph and Telephone Co. plans to start its Digital Data Exchange Packet Switching Network next April in major cities, although Japanese observers expect it to be at least two years before the service goes nationwide.

Private enterprise

As the data-communications facilities are being put into place, so are the various companies' network architectures and distributed processing products.

Next April, for instance, Britain's International Computers Ltd. plans to launch its networking package. Intended to interconnect all ICL computers hierarchically, it will allow them to share files and other resources. Typically, a cluster of up to 1,500 terminals might be connected to a stand-alone model 2903 small computer, which acts as a satellite and in turn is connected to a remote mainframe 2960 computer.

Industry observers agree that the environment is particularly favorable to distributed data processing in France. First, the imminent implementation of the Transpac network and its distance-independent tariff structure is seen as encouraging the technique. Also, political weight is being put into encouraging the development of a distributed computing industry and its use by small and large companies as well as the government. Finally, because of the government's regional development policy, French president Giscard d'Estaing has exhorted users to put their computing power in the provinces rather than the computer-saturated capital. Currently 85% of the French computing power is located in the Paris region, industry members say.

In France and Germany

To meet this growing need, the French mainframe manufacturer, CII-Honeywell Bull, basically uses the same network support systems—Distributed Systems Environment (DSE)—as its 47% U. S. shareholder, Honeywell Information Systems Inc. CII-HB officials, however, agree with their U. S. counterparts that DSE is not yet fully developed.

Hints of what the DSE will look like when it is finished come from a company official who declares, "Products offered by CII-HB will be very close to the distributed systems architecture as defined by the International Standards Organization" (see "Standardizing network etiquette," p. 120).

What is claimed to be Europe's most comprehensive distributed processing network is currently being built in Germany. Called ITS, for Integrated Transport System, it is intended for the German Federal Railways and will encompass about 6,000 data display stations supplied by Triumph-Adler and computers and other data-processing hardware from Siemens at the national, regional, and node levels. ITS will cost more than $130 million.

In other applications, the number of nodes, or communications computers, that Siemens AG's Transdata network can handle is 32. To these nodes, as many as 2,000 display stations in all can be connected. The network may be managed either by a single, dedicated, centralized computer or by the individual data-processing systems, says Herbert Donner, product planning manager for general-purpose data processing at Munich-based Siemens. It uses specific protocols such as the High-Level Data Link Control.

Not only Siemens but also Nixdorf AG is pursuing the distributed processing market. Basic to its modular Nixdorf Communications Network is the X.25 packet-switching protocol. It also has standard interfaces and uses the High-Level Data Link Control protocol.

"With NCN there is no limit on the number of transport nodes," says Dieter Kaden, sales manager for distributed processing systems at Paderborn-based Nixdorf. The number of terminal nodes or cluster controllers, however, depends on the network application—so far, 200 has been about the maximum. In an NCN terminal network, a dedicated terminal can direct the "management" control functions, but the host performs network control.

In Japan

The Japanese distributed processing market is not as ripe as that in the United States because Japanese computer makers are just starting to manufacture distributed processing products.

Nippon Electric Co.'s entry is called DINA, for Distrib-

Standardizing network etiquette

In a network of computers, data bases, and terminals, all the elements have to obey a common code of behavior. This protocol tells them the proper way to address each other so as to guarantee a response and specifies which has precedence over another in what circumstances. But the protocols of current distributed processing architectures are themselves only partially compatible—to the chagrin of customers when they find it impossible to interconnect equipment bought from different vendors.

Charles W. Bachman, senior staff scientist at Honeywell Information Systems Inc., Waltham, Mass., is clear on what is needed—"standard interfaces and protocols which would permit any person, any terminal, any physical process, and any computer which used these standards to exchange information." As chairman of two subcommittees, he has been busy developing a conceptual framework for the writing of such standards.

Under way. Earlier this year, one of them—the American National Standards Institute's study group on distributed systems—produced its Reference Model of distributed systems, having been set up for this purpose in August 1977 by ANSI's Committee X3, Computers and Information Processing, and its Standards Planning and Review Committee (SPARC). This model became the basis for similar work started by the International Standards Organization's subcommittee on open system interconnection, also under Bachman.

Once approved, the ANSI and ISO models should facilitate the standardization of protocols. As they stand, they are practically identical: both have seven levels, each with a function and an interface to the next layer (see figure). The first four are referred to as the transport service because they provide the means of getting a message from one point in the network to another. The remaining three interface the user to the network.

Level 1, the physical layer, specifies the mechanical, electrical, and functional characteristics required to connect, maintain, and disconnect a physical circuit, or link, between (say) a remote terminal and a computer. It is rather well established in standards such as EIA's RS-422/423 and RS-232-C and the CCITT X.21 protocols.

Once this link is established, the **Level 2** link layer adds addresses to outgoing messages and decodes them on incoming messages. It also provides the ability to detect and correct errors and otherwise control the flow of data across the physical link. Examples of this type of control are ISO's High-Level Data Link Control and IBM's Synchronous Data Link Control.

Level 3 handles network control. It specifies the network addressing and routing through the network, controls errors, and accounts for services received. At this level, the lack of established standards becomes obvious, as almost every vendor handles this in a different manner. Packet-switching networks using the CCITT X.25 protocol are forming a basis for implementing this layer, but X.25 is actually a link protocol and does not provide network control functions.

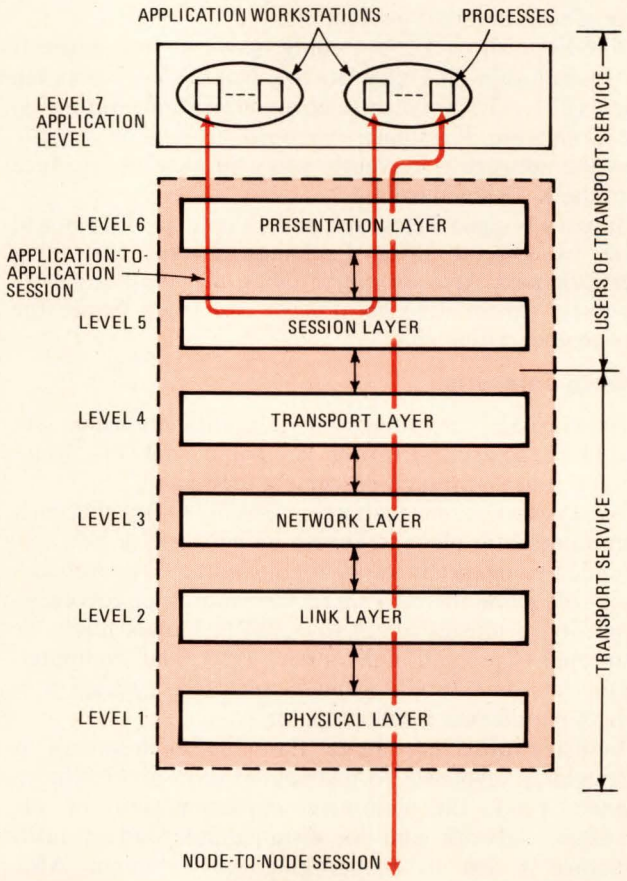
A network-independent standardized interface is outlined by the transport layer, **Level 4**, to allow various computer systems to interface routinely with various data-communications networks.

The next three levels provide the control for application programs or jobs running at a particular computer to interface with the network. **Level 5** for session control supports a dialog, or structured message exchange, between two workstations. **Level 6**, the presentation layer, translates various computer languages, data formats, and codes and handles the transformation between terminal formats. **Level 7**—the only one the user will be aware of—is the application layer, where the computerized processes either generate or receive and interpret the messages handled by the other six levels.

As might be appreciated, the aim of the standards activity and of the various distributed processing equipment vendors is to make the user as unaware of the first six levels as possible. This is analogous to a post office. Once the message is placed in an envelope and properly addressed, the user is unaware of the exact mechanism that moves the letter to the other end. He does not have to know, or indicate, which intermediate offices the letter has to stop at along the way for sorting, nor does the user have to specify the means of transportation.

Goals. At present, as Bachman says, "things are in pretty good shape up to Level 3. From Level 4 up, however, is all new work." The ISO committee completed its model in October and is now circulating it to member countries for comment, with voting scheduled for next November. After that, ANSI will complete its model.

"I'd like to have a draft standard by 1980," Bachman declares. "I realize that by all historic schedules, this is impossible, but I think the motivations are stronger here than ever before." And there is considerable pressure on vendors to offer compatible equipment, he says, basically from large users.



uted Information Processing Network Architecture. It will be compatible with Nippon Telegraph and Telephone Public Corp.'s upcoming Digital Data Exchange and is suitable for use with a mix of small business computers, large mainframes, minicomputers, and intelligent terminals. A unique feature of this network is IMUX, an integrated exchange that includes voice, computer, and facsimile signals. Data and digital facsimile can be handled in a store-and-forward mode.

One system can have up to 1,024 nodes and each computer in the network contributes to management, with centralized control a special case. DINA supervisory protocol is used. For the physical link, HDLC is used, as well as the X.25 packet interface.

Mitsubishi Electric Corp. calls its approach Multishared Network Architecture (MNA). Said to resemble DECnet, it uses a 16-bit address that allows up to 65,536 nodes. Each computer can manage the network, and network control is generally divided among them. Data link protocols used include HDLC, SDLC, and current-loop control; network control uses the Network Access Protocol; and for functional control there are a file access protocol and remote job-entry and network virtual-terminal protocols. Mitsubishi says that not only mainframes but also office computers and minicomputers can be attached to MNA.

Like IBM

Hitachi Ltd.'s Hitachi Network Architecture is very similar to IBM's SNA—in theory, the two may be interconnected, but nobody is known to have done so. It also supports the X.25 packet-switching protocol. Up to 64,000 units can be addressed on the network. When it is used with packet exchange, there is no limit on number of host computers. There is also single network method that limits the multi-host configuration to four hosts.

Fujitsu Ltd.'s Network Architecture (FNA) can also be interconnected with IBM's SNA. Using a hierarchical approach, Fujitsu's M130 through M200 mainframe computers serve as hosts in an FNA system, aided by Communications Control or Universal Communications processors. Subhosts can be the smaller model M130, M140, or M160S computers and a variety of Facom terminal clusters and intelligent terminals can also be attached. FNA can be implemented using leased or dial-up lines or the new DDX and uses the HDLC protocol.

PART 4: WHAT NEXT?

Although the concepts of distributed processing are tied down more tightly than ever before in its brief history, all participants stress they have passed only the first milestone on the long road of development. And it will be harder to measure progress from now on, because most of it has to be made in software.

Computer Automation's Rick Ramras emphasizes the relative importance of software and hardware in these systems by drawing an analogy with the gasoline in a car. "A Mercedes may be a nice car, but it won't go far on a gallon of gasoline. A Volkswagen, on the other hand, with a full tank of gas, will get you there."

"Distributed processing is a very large software task," agrees Univac's Neil Gorchow, who warns that "the software aspects are being underplayed or overlooked." One area he says needs work is the development of a higher-level control language, "a superstructure of commands that can be used to access information throughout a network." But the development of this capability is not cheap. Gorchow says development costs at Univac "have reached eight figures, and that's just for distributed processing software."

Prospects and problems in data bases

Echoing many of his competitors, Gorchow also points to the need to work on data-base management: "These techniques are not well developed yet and are often practiced by the user on a trial-and-error basis."

DEC's Chuck Stein agrees that "the management of a distributed data base isn't fully understood yet even in the R&D area. And if you can't do it on a single computer, it's hopeless on a network." Most data-base management systems today, he notes, can handle records and files, "but what do you do about contention?"

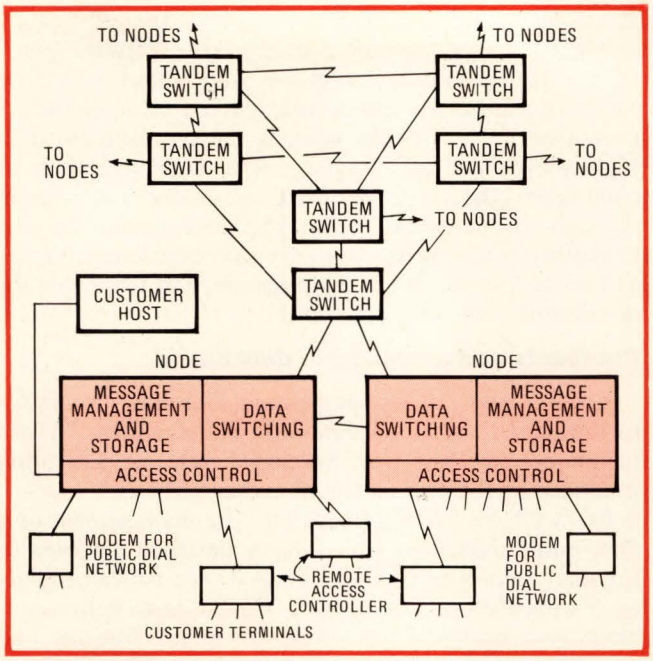
Many data-management systems today duplicate the information in files, which leads to inaccuracies. Work is being done on schemes that would eliminate this redundancy. Another technique under development, called relational data bases, lets the user access a single set of information in a variety of ways. For example, a single inventory file might be referenced by stock number, or product name, or even vendor's code, instead of the same information being duplicated in three files organized in each of those ways.

Backbone development

As the backbone for most distributed processing, computer networking and data-communications techniques still attract much development attention. The aim of many network architectures available today is eventually to make the communications network totally transparent to the user, much like the voice telephone system.

As Stein notes, similar automatic routing techniques must now be applied to computer networks with their variety of data codes, protocols, and line speeds. "The biggest problem with routing is support and control. What do you do, for example, if a node goes down? Many techniques today rely on network maps or routing tables," he says. "But routing has to be general enough to be independent of the transport mechanism."

Not only computer companies but also common carriers are examining these issues. Packet-switching networks, which offer many of these capabilities, are starting up in Europe and Japan. In the United States the only public packet-switched network running currently is offered by Telenet Communications Corp., Washington, D. C. AT&T has announced its intention to offer its Advanced Communications Service, which would provide the code translation necessary to allow dissimilar computers and terminals to link on to a universal switched digital communications network (see Fig. 9). Based on intelligent nodes, ACS would also offer message store-and-forward services. But ACS' future is



9. Help or hindrance? AT&T's proposed Advanced Communications Service would make it possible to attach dissimilar computers and terminals to intelligent nodes that would route messages and store and forward them. Such a network could help the spread of distributed data processing. But some see it as competition for the network architectures and are challenging it on regulatory grounds.

mired in regulatory battles over whether or not it constitutes data processing, an area in which the telephone company is not permitted to compete. The outcome of the battle could be critical to distributed processing; for, although viewed by some as competition to the computer network schemes, according to others the common carriers' efforts could relieve the computer companies from worrying about network and communications considerations and free them to work on the more sophisticated distributed processing functions.

Another portion of data-communications research, Sussenguth adds, is "the work being done in long-delay networks such as satellite links or packet-switching networks." The transmission delay in both averages "a quarter of a second today, yet most networks are designed for only 10 to 20 milliseconds." To handle the longer delays, the protocols used to establish a link and check for errors in messages would have to be made independent of an answer from the intended destination.

Satellite technology, however, offers users not only wider bandwidths but also the ability to change bandwidths fast. "That raises the question of what to do with the extra bandwidth. For instance, instead of the currently used 9,600 bits/s, a satellite can supply a bandwidth of 1.5 to 6 megabits per second, which makes transmitting large amounts of data more feasible."

Microprocessors and computer design

The use of microprocessors will also change the way in which communications is handled in distributed systems. Says Stein, "We're looking at moving all the communications protocol controls to the microprocessor. This will make it independent of the computer's operating system, thereby increasing the system efficiency."

The technique and technologies being developed under the auspices of distributed data processing will have a profound influence on all future computer design. As Jonathan E. Schmidt, Datapoint's vice president for advanced product development, notes: "The rate of hardware maturation has outstripped that of systems design and software. Microprocessor chips today have more power than you can use, so you need some kind of architecture to tie them together." And the network architectures of distributed processing could provide just the models needed.

For such systems to work, the distributed processing techniques of sharing a data base and other peripherals must be perfected, as well as the techniques for program-to-program communications. In these future systems, computers or microprocessors in the network will have to be able to partition jobs, delegating authority for the various parts to the elements of the network, yet appearing to the user as a single computer.

E. Douglas Jensen, senior principal research engineer at Honeywell's Systems and Research Center, Minneapolis, Minn., says the basic computer architecture of the future will use "a multiplicity of processors, physically and logically interconnected to cooperatively execute a single job such that there is global system control exercised by decentralized system elements." An example of such a system, he says, is the Honeywell Experimental Distributed Processor. Consisting of five minicomputers attached to a global bus, the HXDP is currently being used for computer science experiments and, Jensen says, will be made available to commercial users in the beginning of 1979 on a timeshared basis. While other users are trying actual applications programs on the HXDP, Jensen is already working on the design of the next-generation distributed computer, code-named Mercury.

A bus-oriented future

In fact, in a forthcoming data-processing technology forecast he prepared for the Department of Defense, Frederic G. Withington, computer expert at Arthur D. Little Inc., predicts that by 1986, bus-oriented system architectures will predominate. Such systems would use a wide-band, high-speed bus to link various modules that have specialized functions, such as input/output control, memory management, data-base management, system control and maintenance, and general processing. Obviously the geographically dispersed distributed processing systems being discussed today are simply more flexible extensions of these approaches.

General Automation's Maxim Bohlmann agrees that eventually distributed processing systems "from the user's point of view, will appear as a uniprocessor. That's the goal of this work, and that implies a network operating system that can allocate network resources."

Ultimately, warns Univac's Gorchow, the differences between the various approaches will disappear. "It's a lot like the automobile industry. You may be different today, but if what you're doing is good, others will migrate towards it." □

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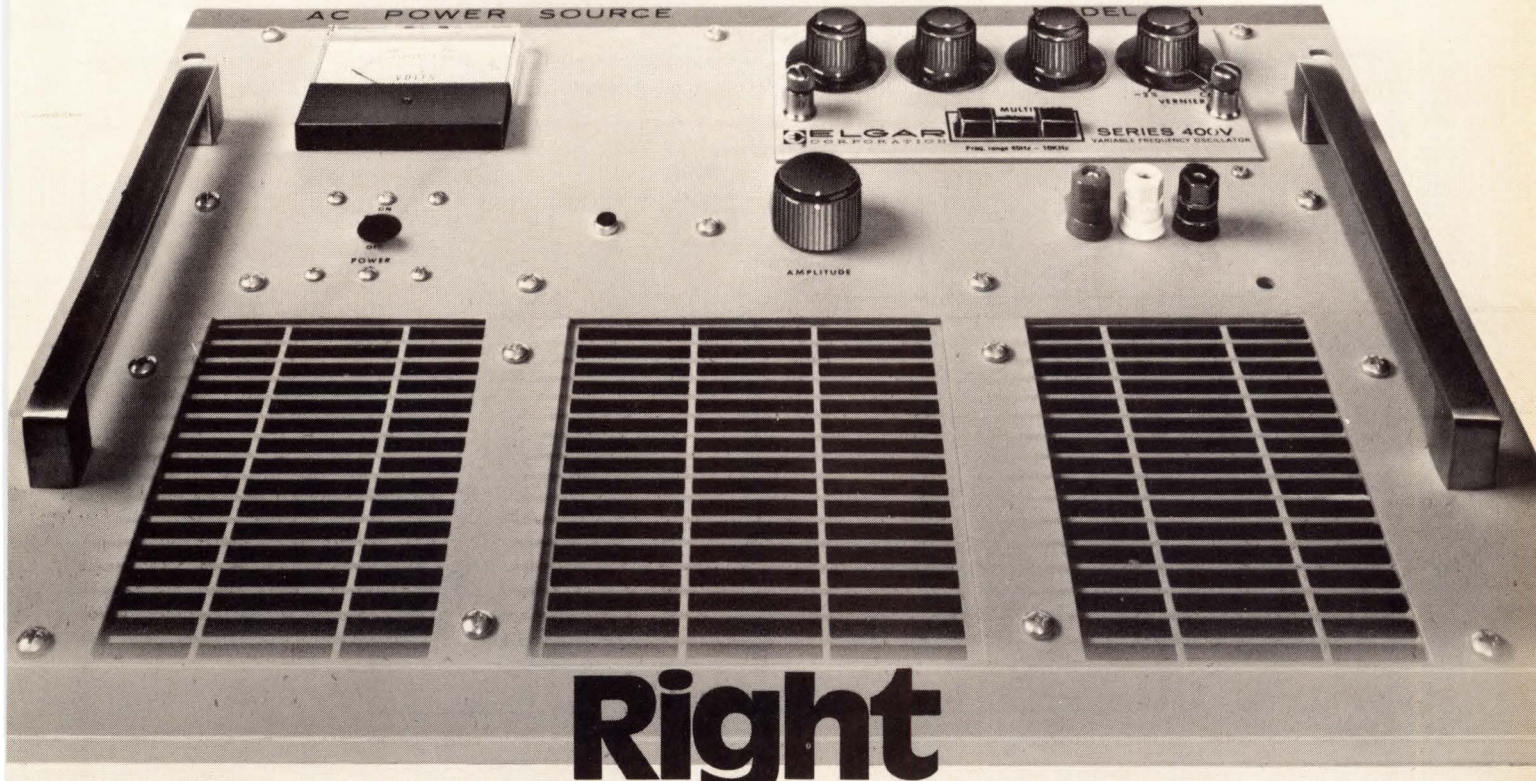


Right from the source.

Circle 123 on reader service card

Wien bridge and op amp select notch filter's bandwidth

by Dominique Fellot
Thomson-CSF, Gentilly, France

The band over which a notch filter provides rejection of unwanted frequencies can be selected with this circuit, which uses a Wien bridge plus an operational amplifier with fixed gain. Such a circuit represents one of the simplest configurations for easily adjusting the selectivity of the filter, which has a notch depth of nearly 60 decibels, independent of component precision.

Circuit operation is most easily described with the transfer function shown in the figure, which is:

$$\frac{V_o}{V_i} = \frac{1-R^2C^2\omega^2}{1-R^2C^2\omega^2+j3(1-k)RC\omega} = \frac{1-x^2}{1-x^2+j3(1-k)x} \quad (1)$$

where $x = \omega/\omega_c = f/f_c = RC\omega$, ω is the frequency of interest, f_c is the center frequency of the notch filter, and k is the percentage of the output voltage from A_1 that is introduced at the noninverting input of A_2. This transfer function has a transmission zero at $f_c = 1/2\pi RC$, which is the center frequency of the notch.

The amount of phase shift provided by the Wien bridge (A_1 and the RC components), from Eq. 1, is:

$$\tan\phi = [-3(1-k)x]/(1-x^2) \quad (2)$$

The width of the rejected band at the −3-dB points can be easily expressed with respect to k by setting $\phi = 45°$, so that Eq. 2 becomes:

$$|\tan\phi| = 1 = [3(1-k)x]/(1-x^2)$$

or:

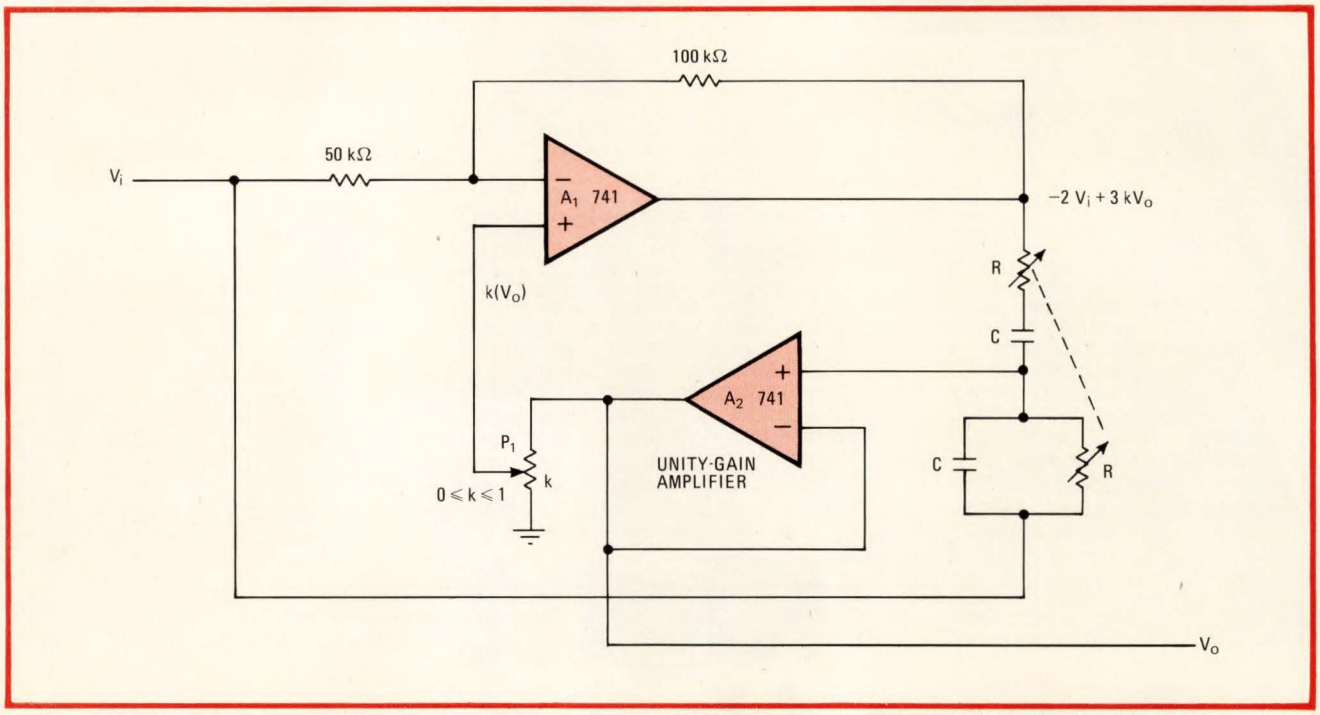
$$k = (x^2+3x+1)/3x, \text{ for } x<1 \quad (3)$$

where $x = f_r/f_c$ and f_r is defined as the difference in frequency as measured at the −3-dB points. Thus, for example, if $f_c = 10$ kilohertz and the desired $x = 0.9$ (or $f_r = 9$ kHz), then k must be set at 0.93.

It will be noted that although the transfer function for the popular twin-T variety of notch filter (not shown) is almost identical to that in Eq. 1 (the constant 3 is replaced by the number 4), in practice, the twin-T is not very easily adjusted. This is because a greater number of components must be trimmed, and more careful adjustments made, to achieve the desired degree of selectivity and notch depth required. □

Designer's casebook is a regular feature in *Electronics*. We invite readers to submit original and unpublished circuit ideas and solutions to design problems. Explain briefly but thoroughly the circuit's operating principle and purpose. We'll pay $50 for each item published.

Selectable stopper. Notch filter, which operates at up to 200 kHz, uses modified Wien bridge to select bandwidth over which frequencies are rejected. RC components determine filter's center frequency. P_1 selects notch bandwidth. Notch depth is fixed at about 60 dB.



One-chip comparator circuit generates pulsed output

by Virgil Tiponut and Daniel Stoiciu
Timisoara, Romania

Generating a steady stream of pulses rather than the usual logic 0 or logic 1 output when triggered, this special comparator circuit is useful in many control applications. The one-chip circuit is perhaps the simplest way to build what is essentially a low-cost switched oscillator.

A 711 dual comparator serves as a Schmitt trigger and rectangular-wave generator, as shown in the figure. The Schmitt trigger (A_1, R_1, and R_2) has switched levels V_h and V_l, given by:

$$V_h = \frac{R_1}{R_1+R_2} V_H$$

$$V_l = \frac{R_1}{R_1+R_2} V_L$$

where V_H and V_L are the high and low output voltages, respectively (at pin 10), $V_H = V_s - 0.75$, and V_s is the comparator's strobe voltage.

The outputs of each comparator are connected in the wired-OR configuration. When the control voltage, V_i, is greater than the user-set reference, V_{ref}, the output of A_2 is low. Thus the output voltage, V_o, is determined by the signals at the input to comparator A_1.

A_1 will then begin to oscillate. The output V_o will move high to V_H because of the small differential voltage that exists across the input of A_1, charging C through D_1 and R_3. When the voltage across C, V_f, approaches V_H, A_1 switches, bringing V_o low. C then discharges through D_2 and R_4 until the voltage across C drops below that at the noninverting input. V_o then moves high again, charging C, and the process repeats.

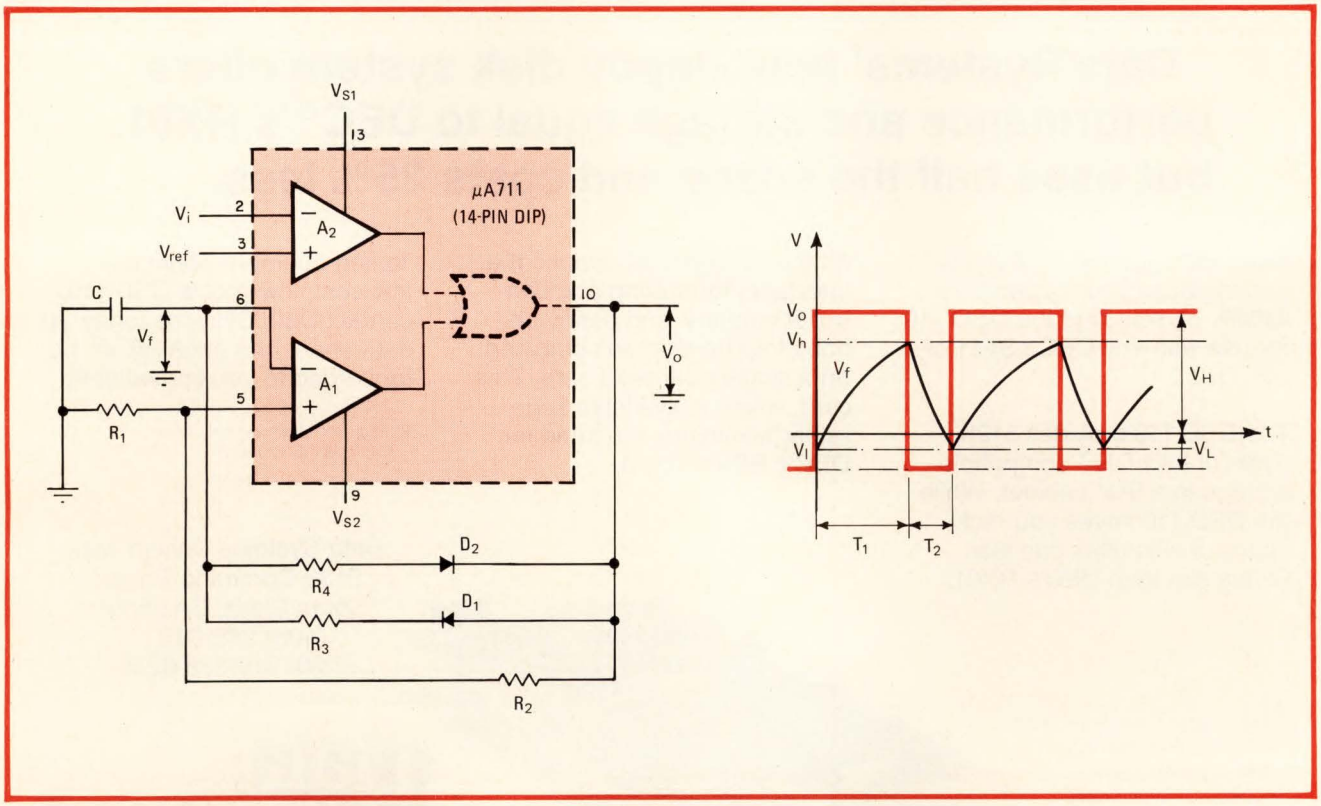
Circuit operation may be visualized with the aid of the waveforms shown. A_1's switching times, T_1 and T_2, are given by:

$$T_1 = C_1R_3 \ln [(V_l - V_H)/(V_h - V_H)]$$
$$T_2 = C_1R_4 \ln [(V_h - V_L)/(V_l - V_L)]$$

neglecting the output resistance of the comparator.

Oscillation ceases when V_i is less than V_{ref}. V_o then moves high permanently, since A_1 is prevented from affecting the output state. □

Pulsating comparator. One 711, wired as Schmitt trigger and oscillator, generates continuous train of rectangular waves when fired by control voltage, V_i. Output voltage V_o otherwise assumes logic 1 (high) state (when $V_i < V_{ref}$). Waveforms detail circuit operation.



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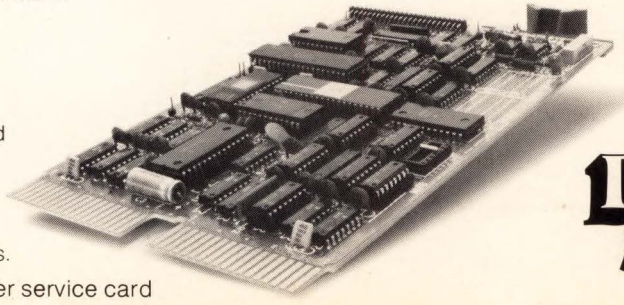

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Data Systems

Removing the constraints of C-MOS bilateral switches

by W. Chomik and A. J. Cousin
Department of Electrical Engineering, University of Toronto, Canada

Two major limitations imposed on the popular complementary-metal-oxide-semiconductor 4016 switch may be overcome with this circuit. As well as allowing the signal magnitude to exceed the power-supply voltage, it enables unipolar control signals to switch bipolar input signals. Only a second switch and an inverter need be added to a standard circuit to remove these operating constraints on the signal-handling gate.

Usually, the signal voltage to be passed through a single switch must be limited to between $V_{DD}+0.7$ volt and $V_{SS}-0.7$ v, where V_{DD} is the positive supply (drain) voltage and V_{SS} is the minus supply (source) voltage. Otherwise, the signal voltage will cause the forward biasing of the diode between the substrate and channel of one MOS field-effect transistor, and the gate may be destroyed.

This problem might arise if the power-supply value applied to some active element in a circuit happened to lie outside the voltage range that could be applied to the switch ($V_{DD}-V_{SS}$), dictating that the gate must be protected from input and control signals that saturate to the supply level.

Furthermore, many circuits, especially those containing operational amplifiers, use bipolar supplies. The resulting signals to be processed are likely to be bipolar as well. Yet the channel-voltage constraints inherent in the design of the 4016 (that is, the fact that the logic 0 control voltage, V_{SS}, must be at or below the most negative signal voltage, and the logic 1 control voltage, V_{DD}, must be at or above the most positive signal voltage) means that bipolar supplies and control signals must also be applied to the switch if these bipolar signals are to be passed. Unfortunately, too, many systems use digital control signals that are unipolar, and so logic-level shifters are needed also, to make this signal symmetrical with respect to ground.

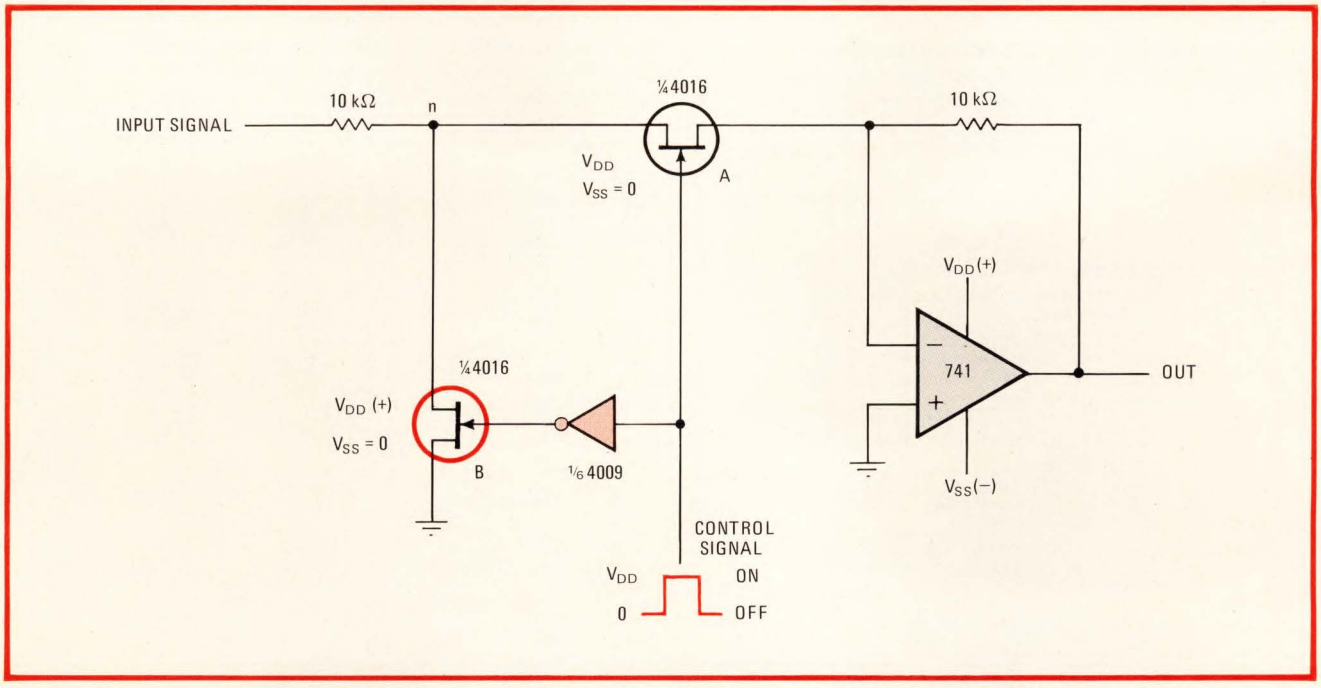
With the addition of a second bilateral switch and an inverter to a standard op-amp circuit, as shown, the signal-handling switch can operate from a single power supply and be driven by unipolar logic at the control input in order to pass bipolar signals. Moreover, the signal can lie outside the $V_{DD}-V_{SS}$ limit of the switches.

The channel voltage of both switches is set by fixing their drain potentials at the virtual ground of the op amp or to circuit ground, depending on which switch is on. Because the virtual ground never strays from true ground by more than a few millivolts, the switches will be protected from burn out, as their channel-voltage limit will never be exceeded.

When switch A is on and switch B is off, node n will be essentially at ground potential. When B is on and A is off, the signal is removed from the op amp's input, but node n will still be at ground (through B), and the same channel-voltage conditions will prevail.

Note that the actual input voltage to the gate at node n will never drop more than a few millivolts below the minimum control voltage, even if the input signal is negative. Thus, the gate's channel-voltage constraint is always met. □

No limitations. Inverter and gate B enable switching of bipolar input signals by unipolar control signals at gate A and also allow magnitude of input to exceed gate's supply voltage. Node n is held near to ground at all times, so that channel-voltage limit of gate is never exceeded. Magnitude of signal at node n never exceeds control-signal potential, enabling gate to switch properly.



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DO-T200	Plug-in — TO-5 pattern. Ultraminiature transformers and inductors for transistor style circuitry.	.125 oz. (3.54 gm)	.35 in. d x .56 in. h (8.9mm d x 14.3mm h)	300 Hz to 20 kHz	100 mW @ 1 kHz
DI-T	Flexible 1½" Dumet leads, Goldplated. Ultraminiature transformers and inductors for transistor circuitry.	.067 oz. (1.89 gm)	.31 in. d x .25 in. h (7.9mm d x 6.4mm h)	400 Hz to 100 kHz	500 mW @ 1 kHz
DI-T200	Plug-in — TO-5 pattern. Ultraminiature transformers and inductors for transistor circuitry.	.067 oz. (1.89 gm)	.31 in. d x .38 in. h (7.9mm d x 9.5mm h)	400 Hz to 100 kHz	500 mW @ 1 kHz

TRW INDUCTIVE PRODUCTS

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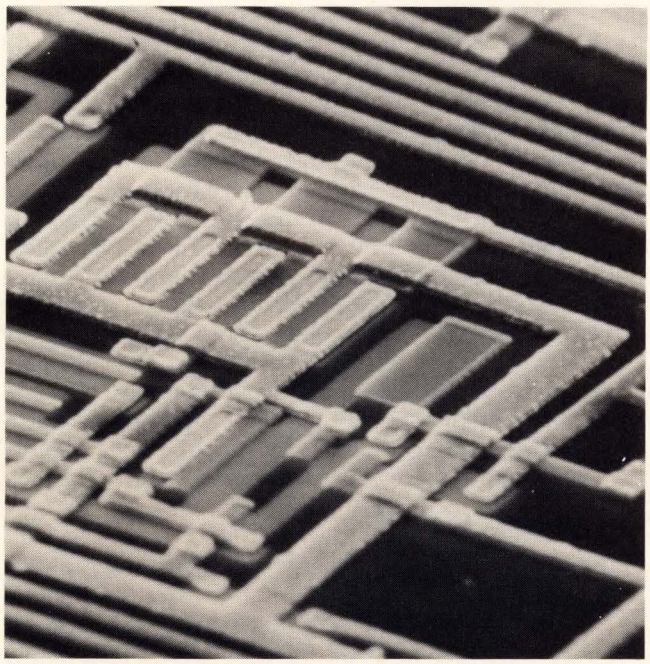
Devices meeting focuses on VLSI, GaAs, and sensors

This year IEDM's papers explore gallium arsenide's advantages over silicon and the best routes to 1-micrometer geometries

by Ray Capece, *Solid State Editor,* *and* Nicolas Mokhoff, *Components Editor*



1. Towards VLSI. This four-phase-array clock is part of a developmental integrated circuit built with electron-beam lithography, ion implantation, and reactive-ion etching. The IC is part of IBM's 1-μm logic program, which is covered in detail by five papers.

□ With large-scale integration commonplace in production parts, the topics at this week's International Electron Devices Meeting in Washington, D. C., are assuredly more esoteric. Circuit integration has graduated to the very large scale, which means 1-micrometer lines and electron-beam lithography; switching speeds ascend to gigahertz levels, where gallium arsenide usurps silicon; and compound materials and techniques arise to build new sensors, energy-conversion devices like solar cells, and power transistors never before possible.

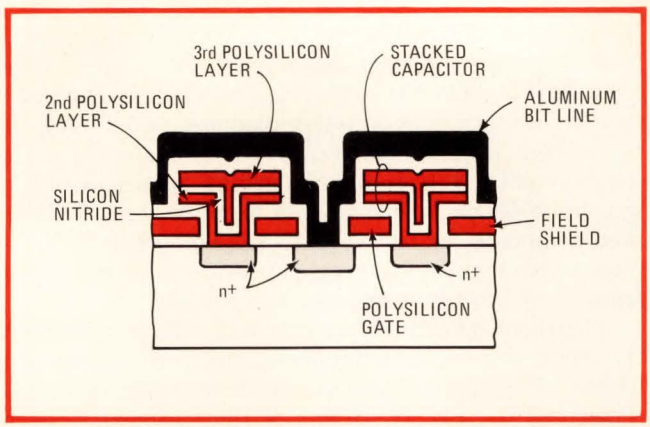
The three invited papers that kick off the conference evidence the new integrated-circuit and component thrust. The first is on fine-line lithography for VLSI. Presented by Alec N. Broers of International Business Machines Corp.'s Thomas J. Watson Research Center in Yorktown Heights, N. Y., it covers the various approaches to the 1-μm threshold that has become the earmark of VLSI. The second paper is on gallium arsenide's future as a medium-scale integration technology with VLSI potential, presented by Richard C. Eden of Rockwell International Corp.'s Science Center in Thousand Oaks, Calif. Eden shows that GaAs transistors' high switching speeds, low power-delay products, and suitability for several field-effect device configurations make it attractive for high-performance digital logic. The last concerns the need for sensor development in the microcomputer age and is given by William G. Wolber of Bendix Research Laboratories, Southfield, Mich.

VLSI the word

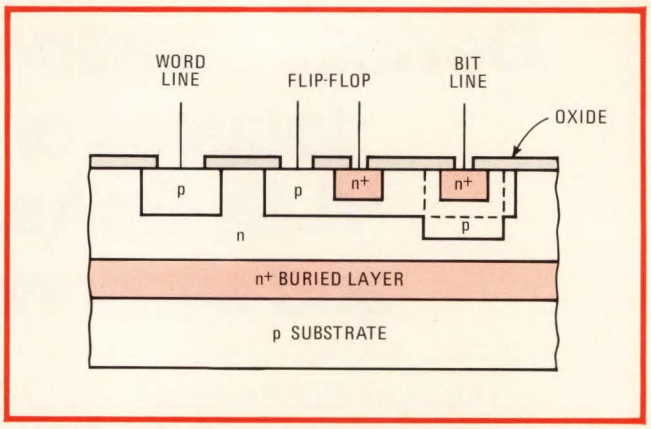
VLSI is the watchword at this year's IEDM, and several papers discuss the various ways of shrinking device sizes to that magical 1-μm dimension. Besides leading the parade with Broers' keynote session, IBM captures nearly half a session devoted to fine-line technology (Session 6) with its Micron-logic program. Just about every state-of-the-art fabrication technique has been employed at the Thomas J. Watson Research Center to obtain the 1-μm linewidths of the metal-oxide-semiconductor field-effect-transistor logic shown in Fig. 1—all lithography is direct-write electron-beam, doping is by ion implantation, and etching uses reactive-ion plasma. The resulting 1-μm logic gates exhibit power-delay products of a mere 0.22 to 0.6 picojoule.

In one paper, H. N. Yu and his colleagues discuss the evolution of the FET down to 1-μm dimensions. All the second-order effects not observed in large MOS FETs are brought in, like hot-electron, trapping, and punch-through phenomena. The conclusion drawn, however, is optimistic: 1-μm transistors are feasible for VLSI.

In another IBM paper at the same session, the details of the process technology are revealed. The key to solving the throughput problem of electron-beam writing directly on chip is held in the resists, and IBM has apparently solved some of the mysteries. W. R. Hunter and his co-workers explain that the lithography performed with IBM's scanning electron-beam system used a double-layer, positive-resist system for four out of five masks. The details of the resist that is put on top of the standard polymethylmethacrylate (PMMA) layer, however, are being saved for a paper to be published later this year in the Journal of the Electrochemical Society.



2. Stacked capacitor. Two bit cells of a Hitachi dynamic RAM are shown in cross section. The triple-polysilicon stacked-capacitor structure builds a 55-μm^2 cell—one third the size of those in 64-K RAMs—that could be the building block for the 256-K RAM.



3. Double-diffused I²L. Using a double-diffused base structure, Mitsubishi Electric Corp. has built a 1,024-bit integrated-injection-logic static RAM with an access time of 20 nanoseconds. Total power dissipation of the 25,000-mil^2 chip is a low 350 mW.

The two-layer approach has two advantages: not only is the IBM resist in the top layer (where the initial developing takes place) more uniform and planar, but it is also more sensitive, allowing exposure doses as low as 2 to 3 $\times$ 10^{-5} coulomb per square centimeter.

W. D. Grobman and others at IBM's research center detail the electron-beam lithography system: how an IBM 1130 minicomputer steps through an addressable grid of 16,000 points at rates of up to 10 megahertz, automatically stepping between chip sites and registering at each to fiducial marks. The standard deviation of the error is always less than 0.15 μm.

A final paper by IBM deals in Session 19 with device performance at micrometer dimensions. R. H. Dennard and three co-workers investigated the performance of 1-μm FETs, as well as just what kind of speed improvements to expect when FETs are cooled to liquid-nitrogen temperatures. They found that cooled devices double or triple in transconductance, improving proportionally in speed, and that this, when combined with micrometer or submicrometer geometries, will make FETs 10 times faster than today's devices with 3-μm channel lengths. IBM, in fact, observed gate delays of 240 picoseconds at room temperature and as low as 100 ps at liquid-nitrogen temperatures.

Japanese contribution

Bringing with them a host of interesting technologies are the Japanese, who are revealing some of the work done under their VLSI cooperative program. In the Central Research Laboratory of Hitachi Ltd., Mitsumasa Koyanagi and Norikazu Hashimoto are working on a one-transistor memory cell design that may be the building block for Hitachi's 256-kilobit or even 1-megabit dynamic random-access memory (Session 14). Called a stacked-capacitor cell, the design uses a triple-polysilicon process (Fig. 2) to get the area down to a scant 55 μm^2 per bit. That compares with 170 μm^2 for a double-polysilicon structure having the same 6.5 ratio of storage capacitance to bit-line capacitance.

The stacked-capacitor cell makes use of self-aligning techniques for both the contacts and the capacitor electrodes. Although the fine geometries are only 3 μm, it doesn't take much figuring to see that a 256-K RAM using stacked-capacitor cells could end up just slightly larger than today's 64-K designs at about 50,000 mil^2.

I²L statics

Engineers at Mitsubishi Electric Corp. are scribing a new static random-access memory built with bipolar injection logic that carries impressive specifications (Session 9). Using a new static cell with a double-diffused base structure, Mitsubishi has attained transistor-transistor-logic speeds at MOS power levels: access times of 20 nanoseconds and write times of 40 ns in a 1,024-bit static RAM that dissipates only 350 milliwatts.

The double-diffused memory cell, whose cross section is shown in Fig. 3, comprises two lateral pnp transistors as load devices and two cross-coupled, inversely operated npn transistors as a flip-flop. The developmental 1-K RAM chip is just under 25,000 mil^2, and that figure will drop as tighter geometries than 4 μm are used.

Still working the electrically erasable programmable read-only memory is Hitachi, and its latest development is a low-voltage, high-speed EE-PROM that can perform write-erase operations with 12-volt pulses of less than 0.1 millisecond's duration. According to M. Horichi and H. Katto (Session 14), the new EE-PROM uses a modification of the original floating-gate avalanche MOS (Famos) design called floating-gate channel-corner avalanche transition, or FCAT. Low voltages and high speeds are attained because the avalanching occurs only at the gate corners (Fig. 4) through a relatively thin oxide. Despite the better read/write times and 500-Å gate-oxide thicknesses, the EE-PROM exhibits good retention characteristics—less than 1-V decay per 10 years in the read mode.

Substrate-fed C-MOS

Reducing the static memory cell from four or six transistors down to three is bound to build smaller static RAMs than ever before, and that's just what Toshiba Corp. is investigating at its Research and Development Center (Session 9). The new cell is a complementary-MOS design that relies on a negative-resistance diode called a substrate-fed C-MOS diode. The diode is made with a complementary pair of weak-depletion transistors.

The diode, together with a transfer-gate transistor and a load element that can be a resistor, a leaky diode, or a fourth transistor, makes up a memory cell. Cell areas of about 2¼ square mils have been achieved, which, though not the smallest, are built with conservative 5-μm geometries. Toshiba says there is lots of potential in the design, however: reducing the linewidths to 3 μm could build a 16-K static that is less than 20,000 mil².

Also in the area of C-MOS fabrication is a paper presented at Session 3 by Alfred C. Ipri of RCA Corp.'s David Sarnoff Research Center in Princeton, N. J. Ipri discusses the fabrication of submicrometer polysilicon-gate C-MOS-on-sapphire devices that do not need submicrometer mask dimensions. Using a self-registering technique, RCA has fabricated both single- and dual-gate MOS devices, and ring oscillators have been built to test delay times. The results for 0.5-μm-gate transistors were delay times of approximately 200 ps and power-delay products (for a supply voltage of 5 V) as low as 0.1 pJ. The neat thing about the process is that, according to Ipri, the submicrometer lines do not affect the overall yield and their continuity is affected only by the original wide-line mask dimension.

GaAs coming on stream

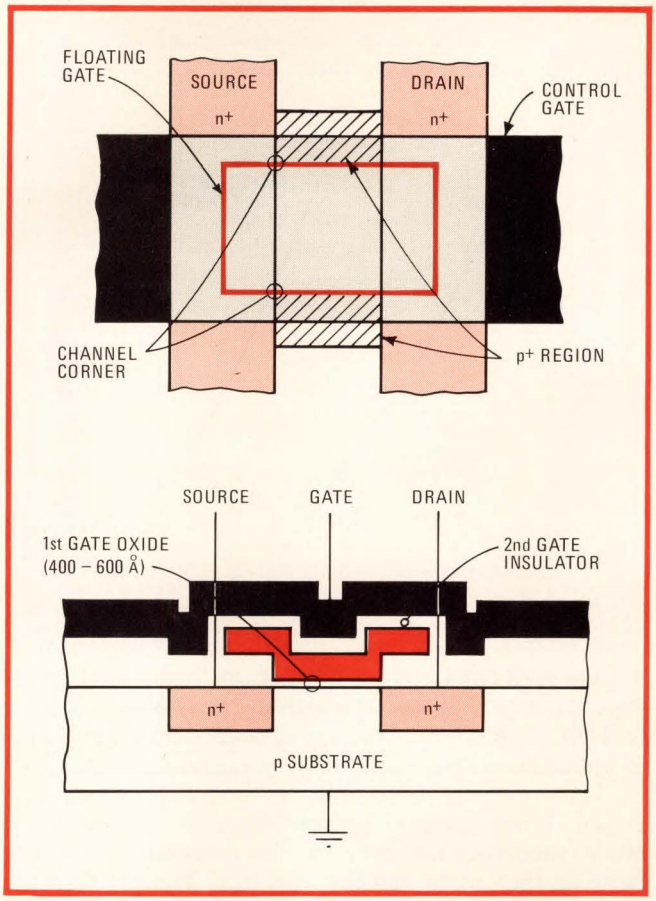
GaAs is also of great interest for its VLSI potential. Two independent studies, one by Rockwell's Science Center and the other by IBM's Thomas J. Watson Research Center, project just what the speed advantage will be if LSI circuits are fabricated on GaAs instead of silicon, using metal-semiconductor FETs, or MES FETs. Although the research is tackled two different ways—IBM uses computer simulations for its projection (Session 8), while Rockwell bases its on actual device measurement (Richard Eden at the keynote session)—both come up with the same answer: all things being equal, GaAs MES FET LSI circuits will exhibit a sixfold speed advantage over silicon MES FET circuits for the same power-delay product [*Electronics*, Nov. 23, p. 41].

The gate delays and power-delay products of the enhancement-mode MES FETs are orders of magnitude better than those of today's n-channel transistors—but the devices are formed with gate widths of 1 μm and less. Rockwell expects, for 1-V logic swings, gate delays of 60 ps and power-delay products of 35 femtojoules (Fig. 5) in its 1-μm MES FET technology. The GaAs program at the Science Center has an aggressive goal of putting no fewer than 1,000 gates on a GaAs substrate within two years—and integration certainly won't stop there.

Sensors in the spotlight

Reflecting the growing importance of fiber optics and optical communications, more papers than ever before in the four sessions on sensors and detectors deal with optical applications of GaAs devices. Of the silicon devices, perhaps the most interesting is a novel, pH-sensitive chemical sensor.

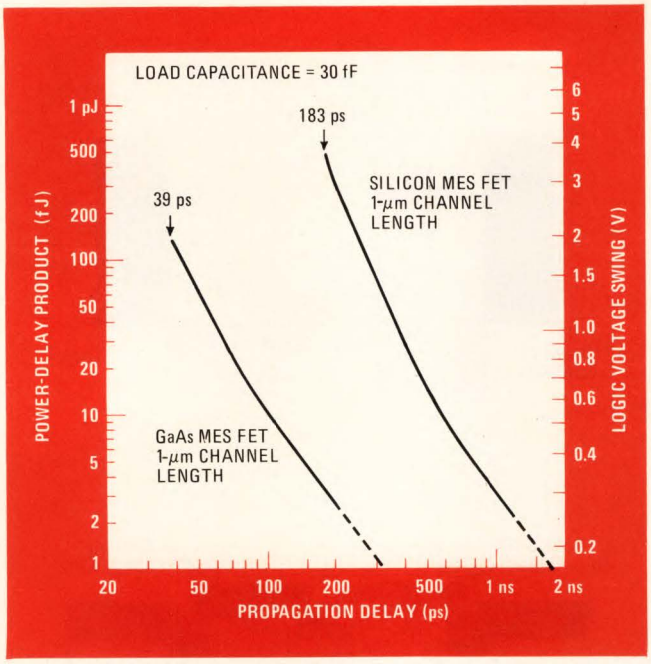
As indicated earlier, in his broad overview of the present state and probable future of sensor technology, William G. Wolber of Bendix Research Laboratories makes much of the deficiencies of silicon sensors in relation to the coming wave of microcomputer-based



4. New EE-PROM. Building its device so that avalanche occurs at channel corners (top view), Hitachi has made an electrically erasable programmable read-only memory that writes and erases with 12-V pulses of 0.1-ms duration. The device is called an FCAT.

control systems. Temperature variations throw such sensors wildly off, he observes, so that other semiconductor materials are being investigated in conjunction with different methods of fabricating large-scale integrated circuits. But where temperature is not an important factor, Wolber predicts the control system sensors will no longer be remote from the control system—rather they will contain the system, in the form of a silicon microcomputer chip complete with on-board analog-to-digital converter. These smart sensors will make it possible for the engineer to design in such dedicated features as the integral autocorrelation, cross correlation, and matrix inversion used in signal-processing applications without worrying about cross-parameter effects or the need for inherent compensation.

The chemically sensitive silicon device described in Session 5 is a field-effect transistor developed by C. C. Wen, T. C. Chen, and J. N. Zemel at the University of Pennsylvania's Moore School of Electrical Engineering in Philadelphia. Intended for use in biomedical instrumentation, chemical process control, and pollution detection, the FET responds to increasing alkalinity or decreasing acidity with either a change in gate voltage or a change in bias frequency. Actually, the differential admittance of the FET's source-substrate diode is measured by means of a capacitance bridge and a lock-in amplifier. Figure 6a shows the ion-control diode configu-



5. GaAs MES FETS. IBM and Rockwell both predict these devices with 1-μm gates or smaller will provide six times the speed of silicon MES FETs or MOS FETs. As implied by graph, GaAs advantage can be used either for higher speed or for lower power-delay product.

ration. When the gate voltage biases the device on, the admittance becomes only the pn junction capacitance between the source and the substrate. The pH response then is measured both as a change in the gate voltage at a fixed value of substrate capacitance and as a change in the bias frequency needed to maintain a fixed capacitance. The experimental results for a frequency of 20 kHz show a nearly linear relationship between the pH and the gate voltage (Fig. 6b).

When it comes to photosensitivity, though, gallium arsenide is in the lead. Extremely promising for optical communications, for instance, is a fast, 10-ps optical detector called an OP FET (Session 5). Developed at Cornell University, Ithaca, N. Y., by J. C. Gammel and J. M. Ballantyne, it is actually a metal-semiconductor GaAs field-effect transistor that outperforms p-i-n photodiodes and does about as well as the silicon avalanche photodiodes generally used as a detector for wide bandwidth and long-distance fiber-optic transmission. The OP FET's detection mechanism is photoconductivity: optically injected carriers increase the conductivity of the material between the source and drain of the device, resulting in photoconductive gain so long as the transit time for electrons is shorter than the lifetime of holes in the device.

Another possible replacement for the silicon avalanche diode is an aluminum GaAs heterojunction phototransistor (Session 25). It is built with a new fabrication process developed by R. D. Dupuis and P. D. Dapkus of Rockwell International Corp. in conjunction with a group from the department of electrical engineering and materials research laboratory at the University of Illinois, Urbana. Metal-organic chemical-vapor deposition (MO-CVD) grows AlGaAs-GaAs heterostructures with very thin layers of high-quality materials, resulting in a device capable of optical gains on the order of 200.

Fiber-optic data communications, or to be more specific, the generation of narrow, high-data-rate optical pulses, was the application envisioned by I. Ladany and his co-workers at RCA Laboratories in Princeton, N. J., for their hybrid driver-modulator (Session 25). Composed of a GaAs MES FET amplifier plus a single-mode laser, it delivers 1-ns pulses at 500 megabits per second into a single-mode optical fiber. The laser operates in a single mode in both the lateral and longitudinal direction, which makes the narrowest possible single spectral line—0.09 Å. The active region was constricted by etching a double groove into the bare n^+ substrate (Fig. 7). Coupling into the fiber is done efficiently through a hemispherical lens fabricated onto the end of the fiber.

The MES FET amplifier provides a current gain of 2 while the laser bias level on the amplifier is adjustable over a range of 50 to 200 milliamperes, with a typical modulation level of 30 mA applied to the laser. This yields a peak power output of 1 to 2 mW.

Work on microwaves

Nor is gallium arsenide being neglected for microwave communications. In Session 6, two papers from Japan discuss a beam-lead GaAs Schottky-barrier mixer diode for super-high-frequency band operation and the possibility of insulated-gate FET ICs, while a third, U. S. paper indicates the possibility of integrating a complete microwave receiver on a GaAs chip.

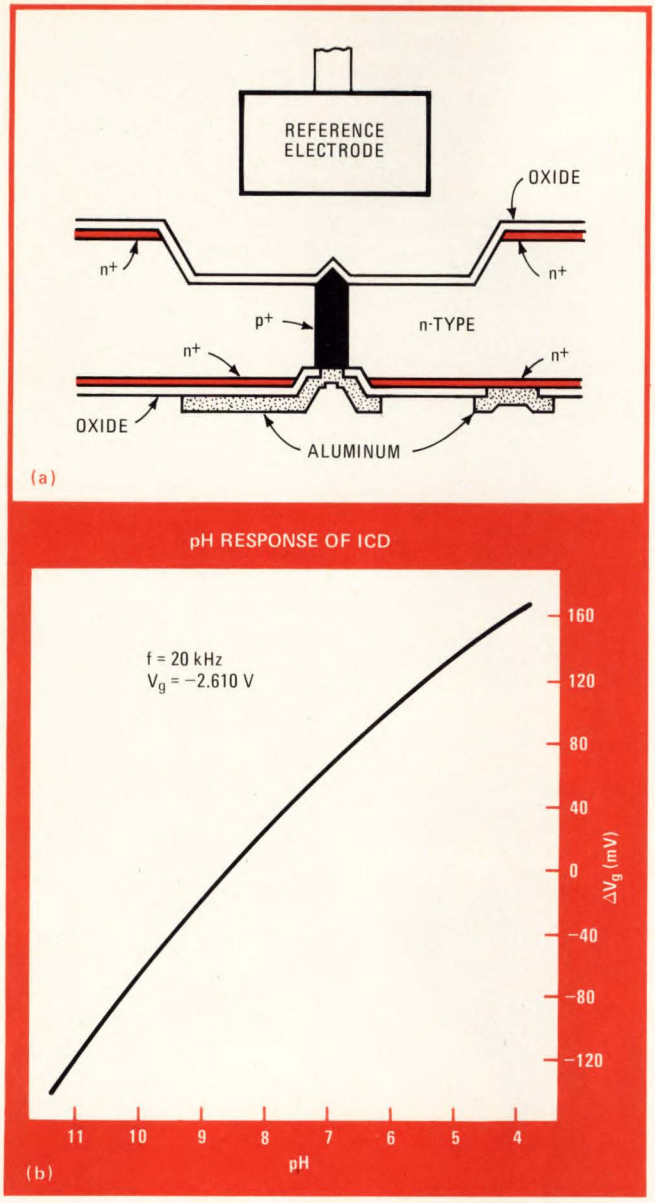
The diode is the work of Sanyo Electric Co.'s Research Center, where Y. Harada and H. Fukuda were able to stretch its cut-off frequency to 2,000 GHz. They achieved this by growing a tin-doped active layer and a tellurium-doped buffer layer on an n^+ GaAs substrate by a liquid-phase double-epitaxial method using a super-cooling technique. The ohmic contact is formed by depositing gold for the required thickness. The Schottky contact is gold-titanium and 10 to 15 μm in diameter.

Double epitaxial layers and thick polyimide insulating film keep the diode's series resistance and stray capacitance to 0.5 ohm and 0.03 picofarad. Its noise figure is 4.3 decibels in down-converter applications for receiving high-resolution television satellite broadcasts.

The insulated-gate FET, from T. Sugano and two other researchers at the University of Tokyo and Hitachi Central Research Laboratories, is also built on GaAs photolithographically. The native oxide film on the GaAs surface is grown by anodic oxidation in oxygen plasma. Using a dry-etching process, IG FETs with gates 1 μm long and 300 μm wide can be fabricated. In all, the achievement shows the feasibility of fabricating GaAs integrated circuits using IG FETs.

Surface-oriented Schottky-barrier diodes are being developed by R. A. Murphy and B. J. Clifton of the Lincoln Laboratory of Massachusetts Institute of Technology. To build them, they use improved material growth technology, ion implantation, and proton bombardment isolation. Such devices could be integrated with antennas, transmission lines, and other components to form monolithic microwave receivers that would also be easy to manufacture.

The ideal flat-panel displays are being frantically

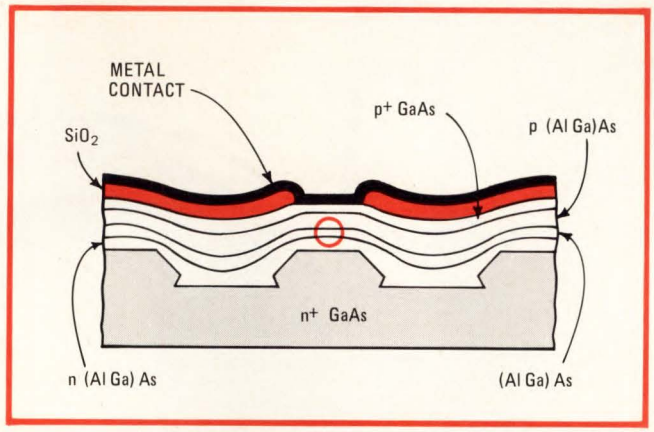


6. Chemically sensitive. With sensor's oxide biased into inversion from a reference electrode (a), the pn junction admittance is function of the bias frequency needed for a fixed substrate capacitance, so pH response depends just on the frequency (b).

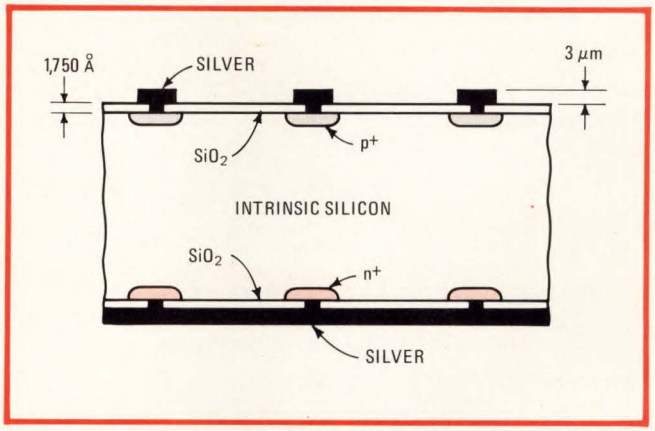
pursued in the research labs as well. Back in the RCA Labs, C. Anderson and A. Pelios are working on a display technology that stretches the basic concepts of a traveling-wave tube into a possible flat-panel cathode-ray-tube display (Session 11).

A TWT-derived display

The idea is to extract the electron beam traveling down the tube at any time by applying a smaller voltage, of opposite polarity to that of the grid voltages, at the place of extraction. This creates the equivalent of a light pipe that can bend the electron beam into whatever geometrical configuration is necessary for a given package shape. The eventual success of low energy and periodic electron beam extraction could result in a feasible flat-panel CRT, once the problems of extracting the three color beams can be solved.



7. Another GaAs application. Laser used in GaAs amplifier obtains lateral mode discrimination from constricted active region: double groove etched into bare GaAs substrate allows driver modulator to emit a single spectral line about 0.09 angstrom wide.



8. Solar cell. To maximize free-carrier absorption and lifetime, photovoltaic cell for use in thermophotovoltaic converter employs p-i-n structure. Tradeoff between efficiency and handling ability yielded 100-μm thickness. Efficiency of 26% outdoes 10% norm.

A paper of special interest in Session 4 is in the as-yet young field of solar energy, specifically in silicon photovoltaic devices. A new silicon photovoltaic cell, for use in a thermophotovoltaic (TPV) energy converter, has been developed by the Stanford Electronics Laboratories of Stanford University, Stanford, Calif. When used in such a converter, the cell should have theoretical energy conversion efficiencies greater than 40%. Measured efficiencies were in the 26th percentile, which compares favorably to the 10% achieved by other such converters. In this conversion, the photocell receives its light from an incandescent radiator operating near 2,300 K—the optimum temperature, because a tradeoff has to be made between the temperature and the cell thickness, which in this case lies between 50 and 100 μm. The active area of the cell is 0.21 cm^2 and can yield an output current of 2 amperes. Because of the free carrier absorption and long lifetime required, a very lightly doped silicon is used for the base region; hence, the p-i-n structure shown in Fig. 8 was chosen. The output density of the device was measured to be 10 watts per cm^2.

As for power devices, Session 26 offers some interesting V-groove innovations in both IG FETs and MOS FETs [*Electronics*, Nov. 9, p. 40]. □

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Microprocessor makes alphanumeric display smart

Bipolar processor controls up to 10 multisegment displays of 32 ASCII characters; user can generate own symbols as well

by William Otsuka, *Monsanto Commercial Products Co., Palo Alto, Calif.*

☐ Friendly displays—alphanumeric readouts that talk the user's language—have grown more popular in point-of-sale, instrumentation, and other interactive applications. But the ability to communicate translates into higher overhead for the terminal's main processor. One way to reserve the processor's power for the computational tasks it was designed for is to add microprocessor control to the alphanumeric display.

A demonstration unit built by Monsanto exploits the speed of the 8X300 bipolar microprocessor[1,2] to drive and control a 32-character readout consisting of four multisegment eight-digit MAN2815 light-emitting-diode displays.[3] This unit exercises all possible permutations of the display, whether it be hooked up to peripheral equipment for on-line display or used as a learning tool to develop different programs for the display. The design process was documented and indicates several important tradeoffs—notably the decision between a metal-oxide-semiconductor processor and a bipolar one.

The type of display selected is important from the standpoint of cost and power requirements. The fundamental choice is between a dot-matrix and a multisegment format.

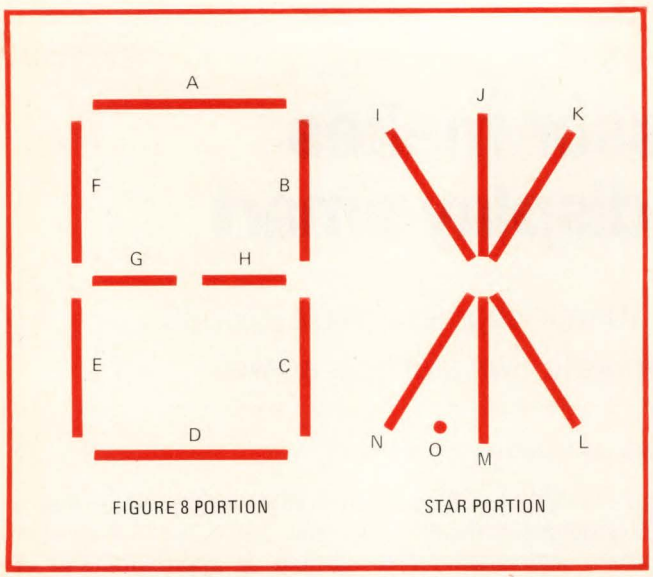
A five-by-seven-dot matrix display, such as Monsanto's MAN2A, offers greater font variety than does a multisegment display like the MAN2815. However, where segmented representations or approximations of curved symbols prove adequate, multisegment units can significantly reduce per digit cost, system power and heat-sinking requirements, and circuit complexity. For example, a segmented design might require addressing and driving 15 LEDs per character versus 35 for a dot matrix. The cost savings that may be realized in moderate- to high-volume applications encourage the use of multisegment displays where possible.

Display considerations

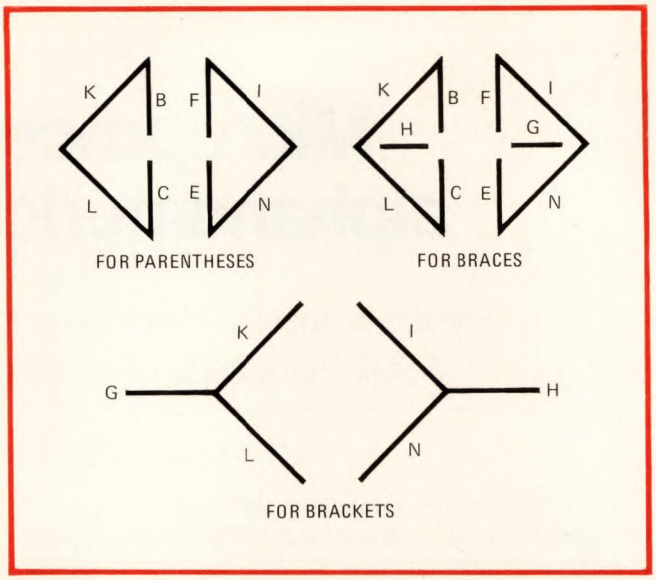
Basic criteria to consider when selecting a multisegmented, multidigit alphanumeric display include total range format of the characters, the relationship between character height and intended viewing distance, and the character spacing needed for the number of characters to be used. Another concern is readability at various viewing angles. If more than eight characters are needed, can one display unit be stacked easily with another, and if so will they maintain uniform separation between character sets? Finally, operation of the display at uniform, acceptable light-intensity levels should reflect minimum

EXAMPLES OF ASCII-TO-15 SEGMENT DECODING

Character	Figure eight portion of digit			Star portion of digit	
	Hex address [lower] (ASCII)		Coding/hex # HGFEDCBA/hex	Hex address [upper]	Coding/hex # ONMLKJI/hex
Space	(020)	000	00000000 = 00	04B	00000000 = 00
Dollar	(024)	004	11101101 = ED	04F	00000011 = 03
Zero	(030)	010	01111111 = 3F	05B	00011000 = 18
One	(031)	011	00000110 = 06	05C	00010000 = 08
Eight	(049)	019	11111111 = FF	063	00000000 = 00
Asterisk	(02A)	00A	11000000 = C0	055	00111111 = 3F
Plus	(02B)	00B	11000000 = C0	056	00000011 = 03
Period	(02E)	00E	00000000 = 00	059	01000000 = 40
Eight	(039)	019	11111111 = FF	063	00000000 = 00
Question mark	(03F)	01F	10000011 = 83	06A	01000010 = 42
B	(042)	022	01001111 = 4F	06D	00000011 = 03
Display test	(---)	044	11111111 = FF	08F	01111111 = 7F



1. Segment decoding. The 15 segments for a character are partitioned into an 8-segment figure eight, labeled A through H, and a 7-segment star labeled I through O. Two NE591 addressable peripheral drivers source current to the two portions.



2. Curved symbols. In multisegmented displays, restricted font variety is overcome by creating approximations for curved symbols. Here, designations for parentheses, brackets, and braces are assembled using segments from both the figure eight and star.

power dissipation and total system cost.

The demonstration unit was designed to exercise fully all of the MAN2815 display's specifications. For the first-time user, a sequence of standard messages illustrate the basic ASCII character set. A keyboard enables real-time field trials and font assessment of the MAN2815 display. This permits the user to create any of 2^{15} possible characters simply by performing a straightforward sequence of key depressions. One keystroke allows the user to observe intensity changes due to a doubling of the time-averaged forward current for any message selected or created. In addition, a display interface permits the display module to be addressed as a peripheral device on a microprocessor input bus.

Defining desired functions

Before selecting the microprocessor, system requirements must be determined from the desired functions. For the demonstration unit, the display had to be refreshed at a flicker-free 200-hertz rate for 32 characters or 480 separate channels (32 characters by 15 segments per character). The microprocessor would have to scan a full-size ASCII keyboard, determine if a key had been depressed, and if so, decode which one. Then, from the decoded information, it would perform a conversion from a lookup table stored in a programmable read-only memory. Finally, it had to supply the key's font to the display, or execute a command in response to a command key. In addition, the microprocessor had to possess enough additional processing power (in the form of idle time) to accommodate additional MAN2815 displays or interface with other equipment or devices.

In comparing component counts, processing execution times, and lines of instruction code for a system implemented with a general-purpose 8-bit MOS microprocessor like the 8080, on the one hand, and one using a Schottky-bipolar fixed-instruction-set microprocessor like the Signetics 8X300, on the other, the only significant difference is in processing speed. An MOS processor typically has a 1-microsecond instruction cycle time, while the 8X300 can execute instructions in 250 nanoseconds.

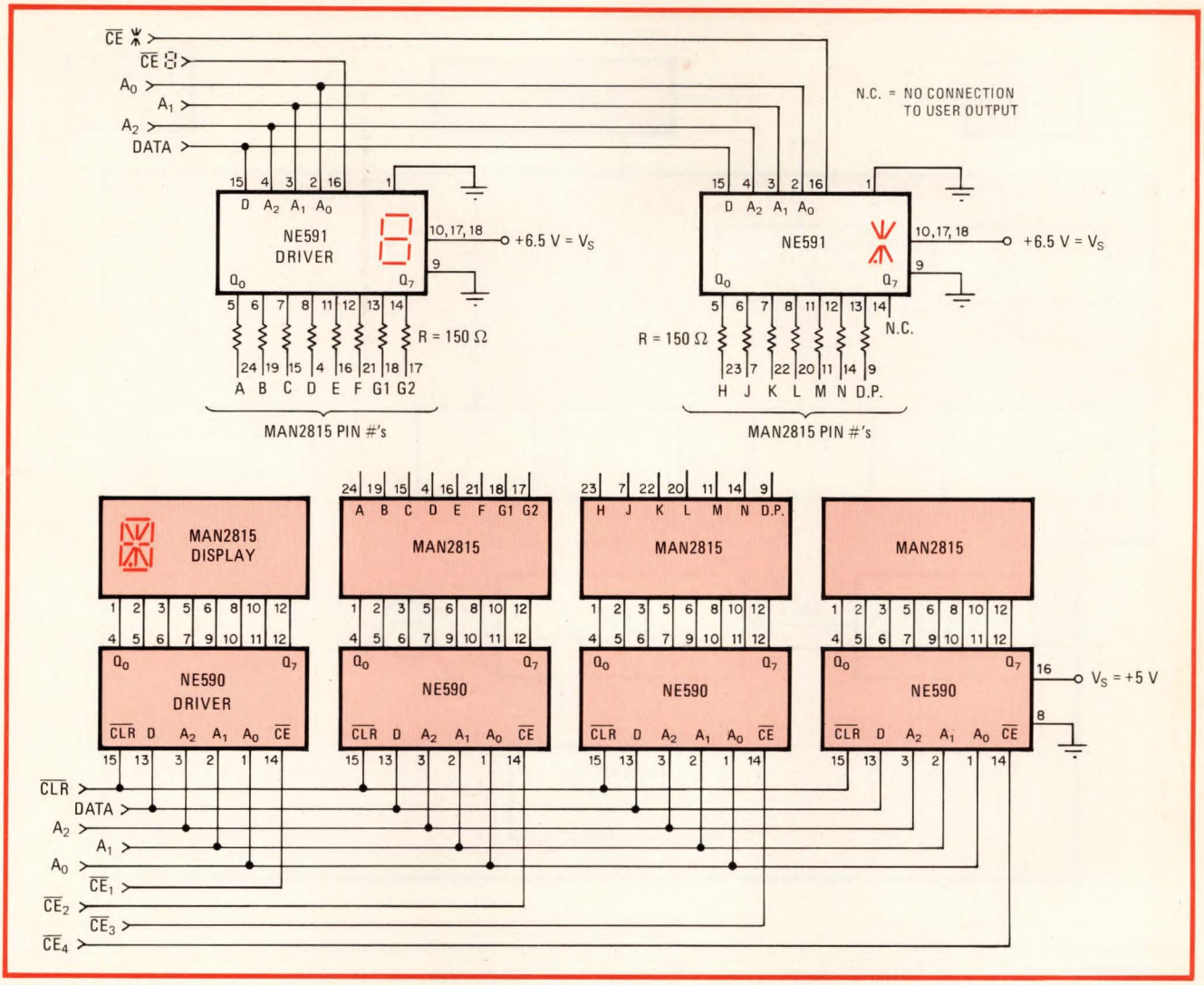
Processor time use

For a display where the microprocessor is dedicated solely to display refresh and keyboard scanning operations, or where not very sophisticated editing is needed, any of the popular MOS microprocessors, such as the 8080, 6800, 2650, 6502, F8, or SC/MPII is highly suitable. For this system design, however, the bipolar device was chosen because its higher speed allows it to perform more on-chip operations.

With a 32-character display and a 200-Hz display refresh rate, each character position is scanned every 5 milliseconds/32 = 156.25 μs. Using the 8X300, the system requires only 13.5 μs to fetch the next character from line buffer and the 15-segment font data (3.5 μs), output the data and select the character position (5 μs), and read and decode the keyboard strobe and character (5 μs). When the keyboard executive is involved, an additional 3 μs are used.

Therefore, worst-case time usage is 16.5 μs out of every 156.25 μs, or 10.56% of the available processing time. This leaves nearly 90% of available idle time compared to 20% for an MOS processor, so the basic system can service up to 10 32-character display groups. Alternatively, other measurements and/or calculations could be made with inputs from peripheral devices tied into the system.

The 8X300-based system also uses fewer parts than would an MOS-based system, because an MOS microprocessor requires external components to interface memory, buffer, and logic ICs. The availability of an 8X300 evaluation board kit, which has a wire-wrap area for interfacing memory and other diagnostics and control



3. Display module. Four MAN2815 15-segment light-emitting diode displays form the heart of the 32-character display-interface module. The 150-ohm resistors provide short-duration protection for the displays should latch-up problems develop.

capability, reduced development time from the design to the final product.

Decoding the ASCII characters into 15 segments is achieved by partitioning the 15 segments into an 8-segment figure eight and a seven-segment star as indicated in Fig. 1. Figure 2 shows segmented approximations for curved symbols. The hexadecimal code equivalents for each portion of the overall font for each ASCII character are then generated as shown in the table.

Font generation

As for font generation, a fixed-address displacement between the two font portions associated with any ASCII character was chosen to permit sequential, or interlaced, call-up of any addressed character during all display-character–related software routines. This was readily achieved since only 3.5 μs were required to call up any character. Furthermore, a single 82S115 8-bit programmable read-only memory conducts this interlacing activity under software control. The software becomes translated into a fixed program (firmware), that resides in the control program (four 512-by-8-bit 82S115 PROMs).

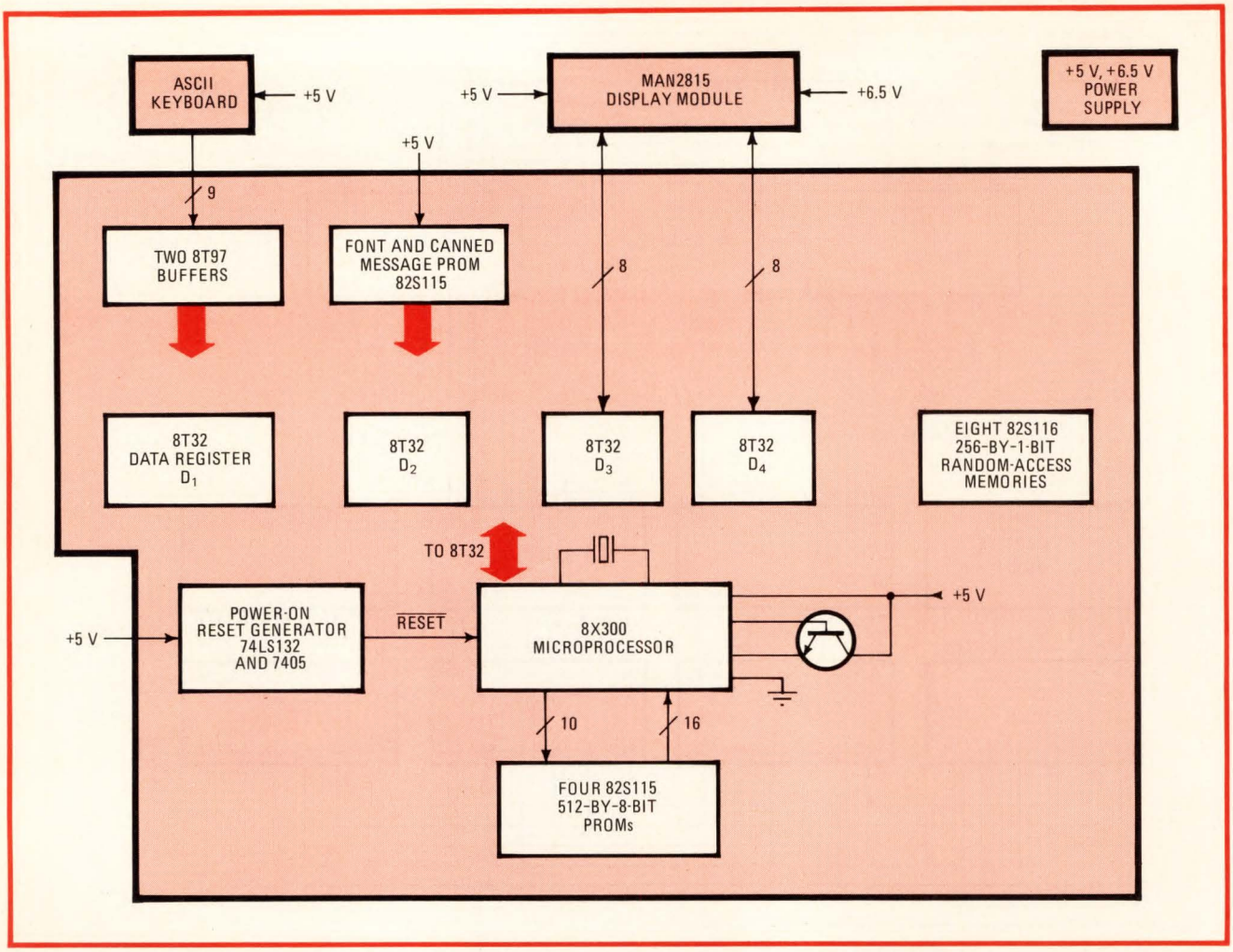
When this interlacing activity is coordinated with the microprocessor's activity by instructions in the control program (organized 1024 by 16 bits), the system generates the fonts associated with each alphanumeric key symbol.

Display module

Figure 3 illustrates the configuration chosen for the four MAN2815s that form the heart of the display-interface module. There are two NE591 addressable peripheral drivers, with two 150-ohm resistor networks that provide short-time protection for the displays should latch-up occur. The NE591s in the display module are used to source current to the figure eight and star portions of each character.

Four current-sinking NE590 drivers select which one of the 32 character positions is to be addressed at any instant during the overall multiplexing operation.

As shown in Fig. 3, the only connections involved are those for address lines A_1–A_2, six active-low chip-enable ($\overline{CE}$) lines, a clear line ($\overline{CLR}$), two data-input lines for turning on or off the Darlington power outputs within the 590/591 addressable peripheral drivers, 5- and 6.5-volt supply lines, and a supply-return line. Thus,



4. Demonstration unit. An 8X300 bipolar microprocessor, the brain of the demonstration alphanumeric display, uses only 10.56% of its available processing time to control the 32-character display. Expansion to 10 such displays is thus possible.

with a total of 15 signal lines that are readily configured for termination using conventional flat cable and connectors along with the 5-V, 6.5-V, and supply ground lines separately provided, an addressable peripheral display is made.

System operation

A simplified block diagram of the microprocessor-controlled alphanumeric display system is shown in Fig. 4. A 63-key keyboard with ASCII-encoded output was chosen for operational control. Seven-bit ASCII coding was used, together with strobe and E output lines. The E line allows designer-created non-ASCII codes, such as BREAK, CLEAR, HERE IS, and the two blank keys, to appear on the same bus as the ASCII codes. The ASCII-encoded output from the keyboard becomes the raw data input to the four 8T32 bidirectional data registers, D_1–D_4, via the 8T97 buffer ICs. This data is converted by software into the appropriate character font or keyboard command.

Font/message data for the figure eight and star portions and for the unadjusted ASCII (hex-code) equivalents of the characters that comprise the eight canned messages is stored in an 82S115 font/message PROM.[4] The microprocessor does not differentiate between a keyboard input code or the font/message PROM's output code for a given ASCII character. Which of the two is presented for processing is determined by a control logic signal to pin 10 of D_3 (see Fig. 5).

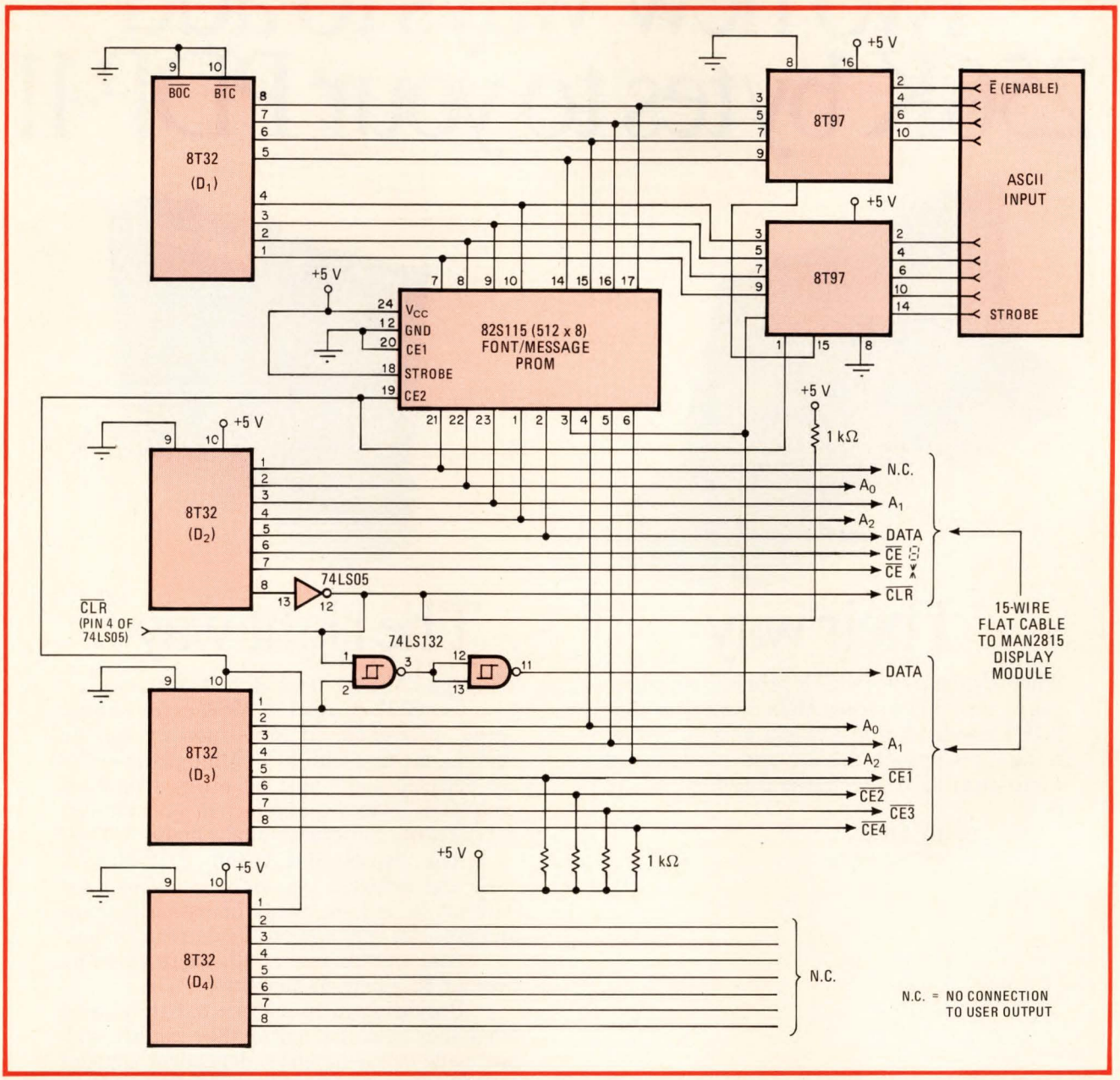
Additionally, this exclusive-OR arrangement assures that no conflict will arise even though the two outputs of the 8T97 and the font/message PROM are connected in parallel to the input/output port of D_1.

Figure 5 indicates the specific configuration of 8T32, 8T97, and 82S115 devices, together with the associated input/output control lines as labeled, that interface to the MAN2815 display module shown in Fig. 3.

The basic functions of D_1–D_4 are numerous (see Fig. 3 again). D_1 serves entirely as an input port. Either the keyboard or the font/message PROM is serviced by this device at any one time. During the power-on initialization the canned messages are stored in a random-access memory. This takes about 50 μs per message.

D_2 serves entirely as an output port. It addresses the font/message PROM for either a message or to pull a font, according to a PROM address. It also supplies the strobing and star and figure-eight data signals to the appropriate 591 driver.

D_3 can be either an input or an output port. Used as an output port, the four $\overline{CE}$ lines to the 590 drivers



5. I/O configuration. Circuitry needed to interface to the MAN2815 display module consists of font/message programmable read-only memory and bidirectional input/output-port integrated circuits that control the data traffic at the four ports.

determine which of 32 positions are to be lighted. Also, the three address lines (A_0, A_1, A_2) to each 590 determine which of eight characters within a MAN2815 is being addressed. A data pin to the 590 determines whether the addressed segment is to be on or off. When D_3 acts as an input port, it monitors strobe signals from the keyboard, via the 8T97. D_4 strobes D_3 only to determine whether it is working with the keyboard input or the 82S115 PROMs, which store the program controls.

Only 773 instructions out of the 1,024 available in the control program store are used in this particular system, so expansion to include additional functions or processing is possible without adding PROM. The eight 82S116s are 256-by-1-bit random-access memories for temporary storage of various system parameters such as pointers, labels, and flags. These system parameters tell the microprocessor what state the system is in, where it is, or where to go once a given operation has been completed. The RAMs are also loaded with character-font data for both figure-eight and star portions from the font/message PROM immediately following power-on initialization. This need be done only once, unless the system is shut off. In addition, the canned messages and user-generated messages are stored here.

Finally, the 32-character display is being controlled within the design constraints put down initially in only 11% of the bipolar microprocessor's processing time, leaving plenty of room for expansion. □

References
1. 8X300 Reference Manual, Signetics, October 1977, Sunnyvale, Calif.
2. *Electronics*, Sept. 1, 1977, pp. 91-96
3. Monsanto MAN2815 Spec Sheet, Palo Alto, Calif.
4. NE590/NE591 Specifications, Signetics, Sunnyvale, Calif.

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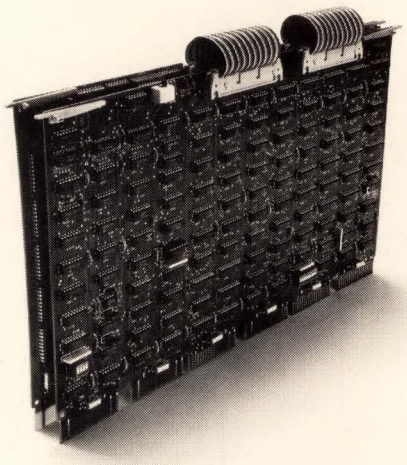

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Standard symbols let designers grasp logic operation quickly and easily

ANSI Y32.14 specifies set of symbols for clearly depicting logic, from gates to systems

by Bill King, *Hewlett-Packard Co., Santa Clara (Calif.) Division*

☐ The more complex integrated circuits become, the greater the detail in which designers and technicians need to understand their workings. To give them that information at a glance, manufacturers must depict the logic operation of their chips clearly and concisely.

In 1973, therefore, the American National Standards Institute approved and published ANSI Y32.14, which set the logic-symbol specifications for most devices—notably gates, flip-flops, and counters—and for systems containing them. But few users are familiar with the standard, because so far it has been adopted by only two manufacturers—by Hewlett-Packard Co. and, to some extent, by Texas Instruments Inc. Nonetheless, since ANSI does set standards for IC makers, its symbolism is likely to become widely accepted.

ANSI Y32.14 specifies:

- Definitions for the basic logic elements.
- Logic symbols, which show the defining shapes corresponding to the logic function performed.
- Qualifiers, which consist of letters, numbers, or arrows placed inside the logic-device symbol to indicate its logic function or special properties.
- Indicators, which show primarily if the input and output are active high or low.
- Dependency notation, which defines the logic-state relationship between the inputs required to activate the device.
- Control and contiguous blocks, which integrate with gates, flip-flops, and other elements to form shift registers, counters, and other commonly used devices.

TABLE 1: BASIC LOGIC ELEMENTS

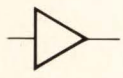
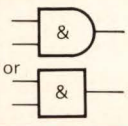
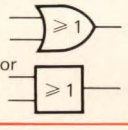
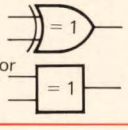
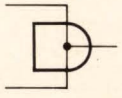
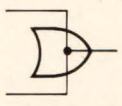
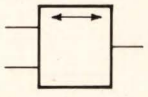
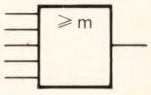
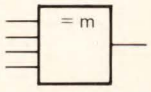
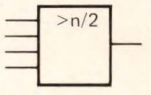
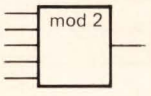
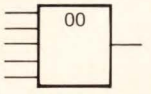
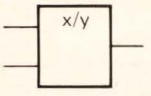
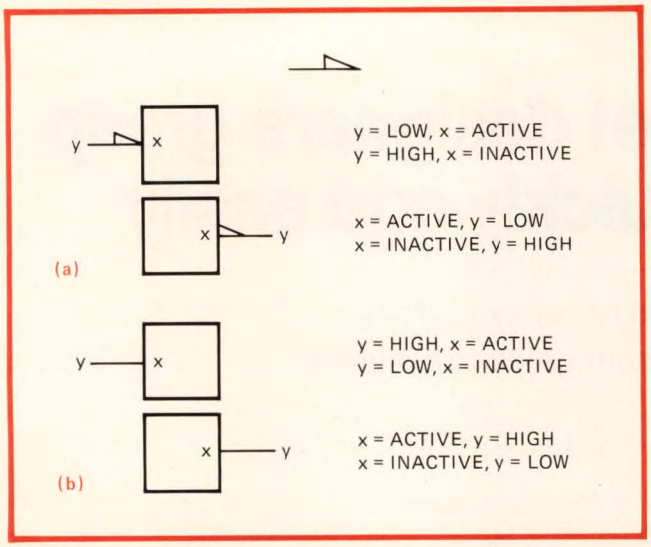
Symbol	Function	Description
	amplifier	The output will be active only when the input is active (can be used with polarity or logic indicator at input or output to signify inversion).
	AND	The output will assume its indicated active state only when all its inputs assume their indicated active levels.
	OR	The output will assume its indicated active state only when any of its inputs assume their indicated active levels.
	exclusive-OR	The output will assume its indicated active level if, and only if, only one of the inputs assumes its indicated active level.
	wired-AND	This is a connection of outputs of two or more elements that are joined together to achieve the effect of an AND function.
	wired-OR	This is a connection of outputs of two or more elements that are joined together to achieve the effect of an OR function.

TABLE 2: SELECTED QUALIFIER DESIGNATIONS

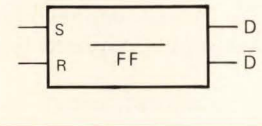
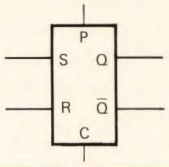
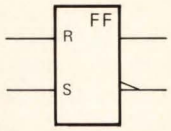
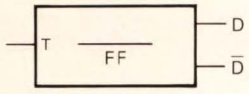
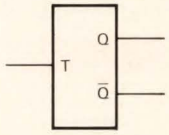
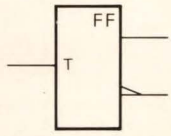
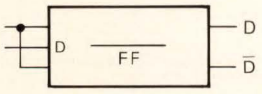
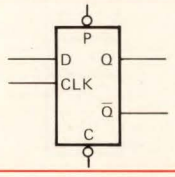
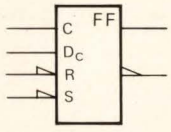
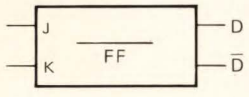
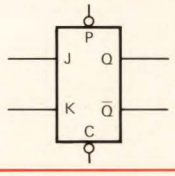
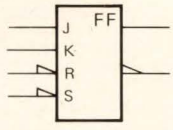
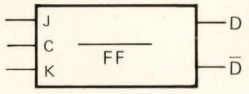
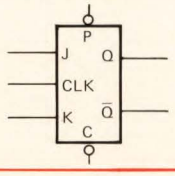
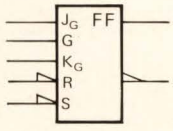
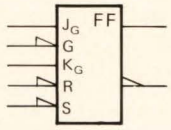
Symbol	Description
	Bilateral switch: a binary-controlled circuit that acts as an on-off switch to analog or binary signals flowing in both directions.
	Logic threshold: output will assume its active state if m or more inputs are active.
	m and only m: output will be active when m and only m inputs are active (for example, exclusive-OR).
	Majority function: output will be active only if more than half the inputs are active.
	Odd function: output is active only if an odd number of inputs are active.
	Even function: output is active only if an even number of inputs are active.
	Signal-level converter: input levels are different from output levels.



1. Polarity convention. Indicator symbol (top) signifies that corresponding inputs or outputs are active low (a), thereby characterizing circuit operation without use of labeled outputs. The absence of the symbol (b) indicates inputs and outputs are active high.

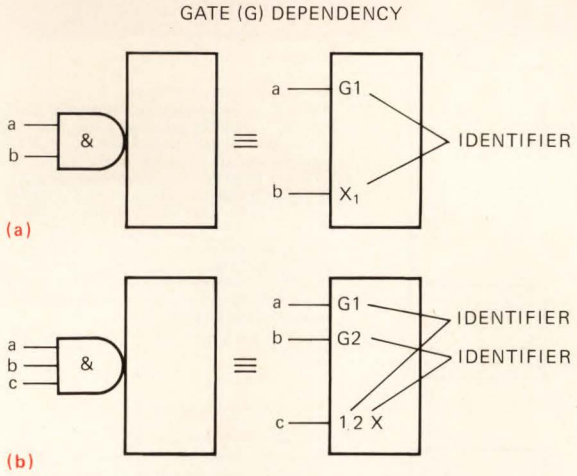
Table 1 gives the definitions of the basic elements—the amplifier, AND, OR, exclusive-OR, wired-AND, and wired-OR circuits—and their logic symbols. Note that the AND, OR, and exclusive-OR can be shown by their assigned shape or by a rectangle, since the presence of an identifying symbol within those elements specifies the device function. The inverting function for these elements (that is, inverter, NAND, or NOR) is indicated by placing the negation symbol (a small circle) at the corresponding output ports of the devices—the same symbol used currently. In addition to specifying the function of a logic element, qualifier symbols are used for classifying logic blocks. Table 2 shows the symbols

TABLE 3: FLIP-FLOP SYMBOLISM

Flip-flop	Original symbols	Previous standard MIL-STD-806B	ANSI Y32.14 Control designations description for flip-flop	
R-S				R S | Q $\bar{Q}$ l l | n.c. n.c. l h | h l h l | l h h h | undetermined
T				Toggling occurs with every clock pulse.
D				Data output follows data input; input is gated by C.
J-K				J K | Q $\bar{Q}$ l l | n.c. n.c. l h | l h h l | h l h h | toggles
J-K (gated)				J and K inputs are gated by C.
J-K (master-slave)	—	—		Outputs are dependent on the negative-going edge of the clock.

n.c. = no change

2. Dependency notation. Block-diagram equivalent of two-input AND gate (a), which drives one-shot, provides quick overview of circuit operation. Identifier indicates dependency between inputs a and b, showing data on b is gated in by a. Approach to coding up three-input AND gate follows logical extension of method (b).

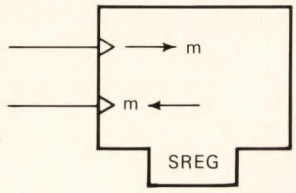


for some of the most widely used ones.

The polarity indicator symbol, shown in Fig. 1 (top), establishes the active states of the input leads required to switch on the logic element or indicates whether the output leads are active high or low. Any input or output so labeled is active low (a). Otherwise, the inputs or outputs are active high (b).

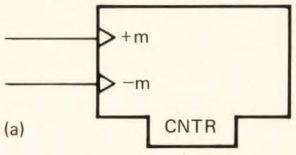
Although this symbol provides the same information as the negation symbol, it offers the advantage of visually representing the signal polarity required to activate the device. Furthermore, it eliminates the inconsistent labeling of logic devices. For example, the inverted

TABLE 4: COMMON CONTROL-BLOCK DEFINITIONS

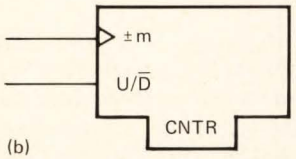


Shift register block

This symbol is used with an array of flip-flop symbols to form a shift register. The data will shift to the right (→) or to the left (←) on the positive-going edge of the input signal.



(a)



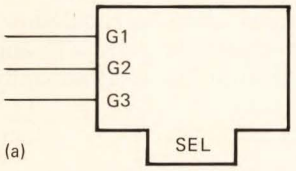
(b)

(not ANSI-defined)

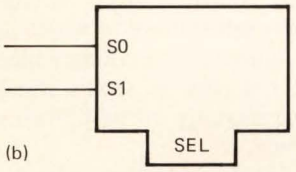
Counter block

This symbol is used with an array of flip-flops or other circuits serving as a binary or decade counter. In (a), the positive-going edge of an input to either the +m or −m input causes the counter to count upward or downward m times.

In (b), a positive-going edge of an input to the ±m port will cause the counter to increment or decrement m times depending on the input to the up-down control (U/$\overline{D}$).



(a)



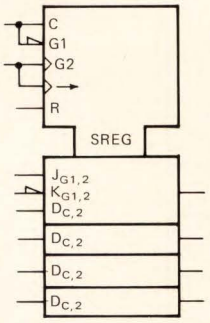
(b)

(not ANSI-defined)

Selector block

This control block is used with an array of OR symbols to provide for the gating lines (a) or selection lines (b). The gating lines have an AND relation with the respective input of each OR function: G1 with the inputs numbered 1, G2 with the inputs numbered 2, etc. The selection lines enable the input designated 0, 1, . . . n of each OR function.

TABLE 5: COMMON DEVICE BLOCKS

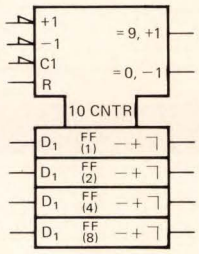


- **4-bit universal shift register**

This shift register has four parallel data inputs (D_C) and two synchronous serial data inputs (J, K). The control block contains those enable lines that will select the way data is loaded into the register. Data entry into the D flip-flops is dependent on C and G2 ($D_{C,2}$). A high input at C and a high at G2 will enable a parallel load on the positive-going edge of G2.

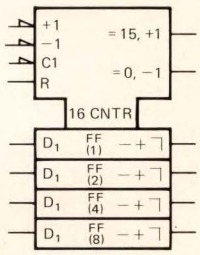
A serial load into the J-K flip-flop is dependent on G1 and G2 ($J_{G1,2}$, $K_{G1,2}$). When there is a low input at G1 and a high input at G2, data is loaded serially and shifted one position to the right on the positive-going edge of G2.

The device resets when there is a high present at the reset.



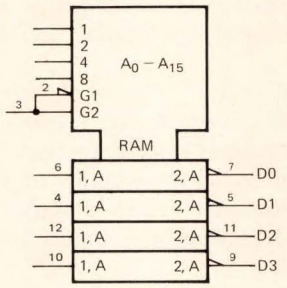
- **Presettable decade counter**

The counter control block is used to show the common inputs to a presettable decade up-down counter. The symbol "+m" means to count up by m and "−m" means to count down by m. (Note: if m = 1, it may be omitted.) The "=9, +1" symbol is the carry output or the terminal count up when the count equals 9. The "=0, −1" symbol is the borrow output or the terminal count down when the count equals 0. C1 is the control input for the D flip-flops and R is the master reset. When C1 is enabled, it loads all four flip-flops (D_1) in parallel. The presence of the output delay indicator is used to indicate that the D flip-flops are master-slave. Flip-flop weights are indicated in the parentheses. The symbol "10 CNTR" indicates that the counter is modulus 10.



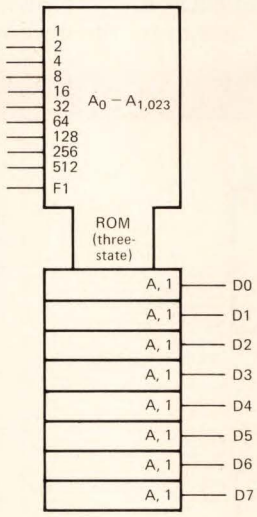
- **Presettable binary counter**

Same as above except that the carry output is indicated with "=15, +1," indicating that the terminal count up occurs when the count equals 15. The symbol "16 CNTR" indicates that the counter is modulus 16.



- **Random-access memory (without identical input/output pins)**

Address selection is determined by the 4-bit address input codes in the upper left corner of the control block. These address codes are weighted to correspond to the possible address (A_0–A_{15}). G1 and G2 are the read/write enable. A low on pin 2 will enable data to be read into the chip in the memory location addressed; a high on pin 3 will enable the chip to output data from the particular memory location addressed. The inputs on the lower left corner of the symbol are labeled 1, A. This indicates that the information will be stored in the memory location addressed. 2, A on the outputs indicates that the data will be written from the memory location when G2 is enabled.



- **Read-only memory**

This is a read-only memory with 1,024 addresses. Address selection is determined by the 10-bit address input in the upper left corner of the control block.

F1 is the three-state enable line. A high signal on this line will enable the outputs. A, 1 on the outputs indicates the dependency on the three-state enable and the memory location addressed.

output of a flip-flop is normally designated $\overline{Q}$, and the inverted R and S inputs have negation symbols at their ports, rather than being labeled $\overline{R}$ and $\overline{S}$. These ports will now be labeled Q, R, and S with appropriate polarity indicators. This change can be seen in Table 3, which shows the development of flip-flop symbolism.

Block form

By providing for dependency symbols and one-block devices, ANSI Y32.14 makes it easier for system designers to understand the operation of large circuits. So-called control blocks, which group the common control inputs, can be joined to contiguous blocks, which depict the remainder of the circuit (an array of gates, flip-flops, etc.). A combination of control and contiguous blocks forms a device block.

Figure 2 shows the application of dependency symbols. Dependency is indicated by subscripts, prefixes, or suffixes. For example, in the case of D_1, the 1 indicates a logic connection between the input, D, and a control line assigned the numeral 1. In prefix form, the notation becomes 1D; in suffix form, D1.

In the simple example of Fig. 2a, a two-input AND gate drives a one-shot multivibrator. The equivalent dependency for the gate is shown to the right. G1 is an input, through which data on line b is gated into the device. The 1 identifies the existence of the relationship between lines a and b, with the letter G defining the type of relationship (AND-gate dependency). The appropriate letter identifies other relationships: A (address), C (control), F (free, or three-state), or V (OR-gate).

Figure 2b, an extension of Fig. 2a, shows how a circuit having a three-input AND gate is coded. G1 and G2 are the gating inputs for data on line c, as indicated by the 1,2 of the input 1,2 X.

Symbol buildup

ANSI's recommended control blocks include a shift register, a counter, and a selector, all of which are shown in Table 4. The lower figures of the counter block and of the selector block are not part of ANSI's standard, but they have appeared occasionally in the literature and so are included for reference.

When these control blocks are united with contiguous blocks, such as flip-flops, then entire devices can be built. Several are illustrated in Table 5. □

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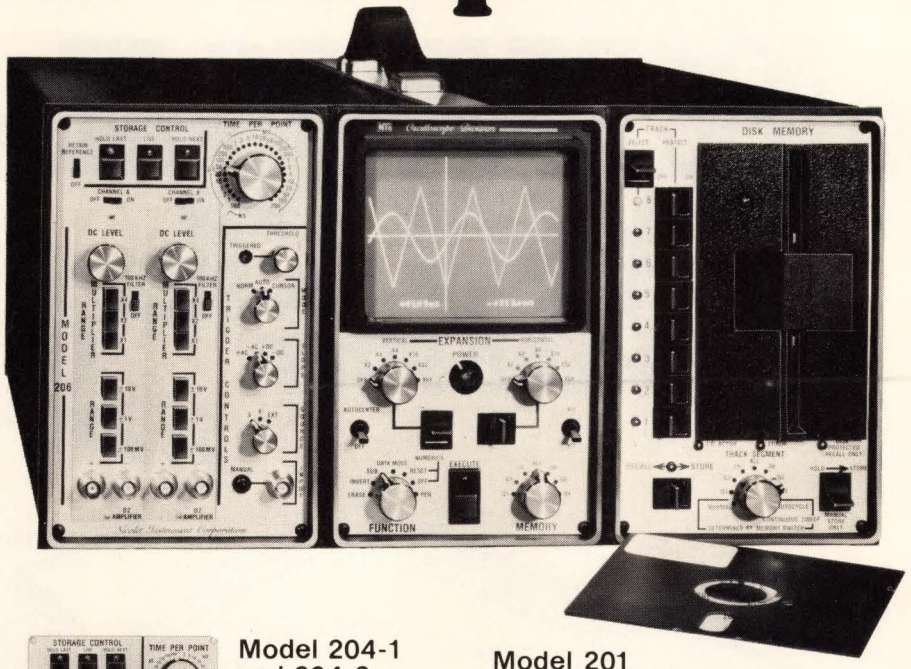

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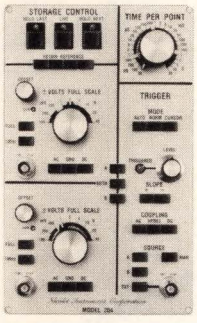

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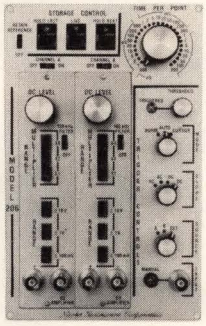
These are one and two input units, with 50 ns rise times, and 10 MHz bandwidth (3 db norm). Resolution is 0.4% and accuracy ±0.5% of F.S. Equivalent storage writing rate (ESWR) 50 cm/μsec.



Model 206-1 and 206-2

These are one and two input units with differential amplifiers, 500 ns rise time and ESWR 5 cm/μsec. Resolution is 0.025%, accuracy 0.2%. Minimum observable signal amplitude 50 μv. Sweep speeds from 500 ns to 200 sec/point.

Model 201

This unit provides two input channels, 50 KHz bandwidth, ESWR 500 cm ms, 5 μv minimum observable signal. Other features are 5 μv/hour; 2 μv/°c drift; 10^9 input impedance; excellent CMRR; and ±0.05% accuracy and 0.025% resolution.

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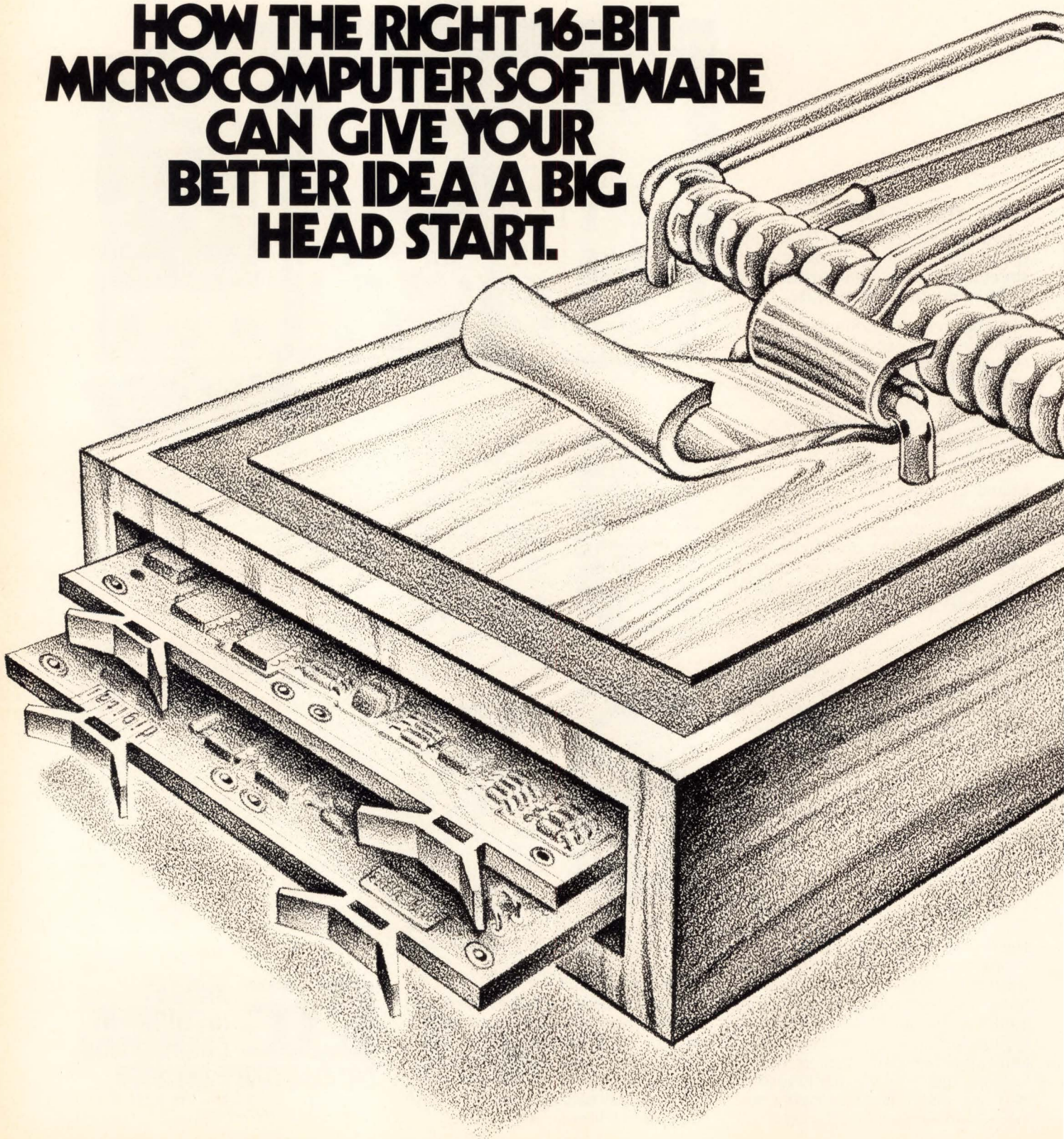

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Circle 149 on reader service card

Design ICs The Super Way

Very large scale integration (VLSI) is forcing changes in IC design.

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Bigger, denser chips mean that laying out a design manually and then digitizing it into a computer is becoming increasingly inadequate. The solution is putting the designer in front of a CRT from the start and eliminating the digitizing step.

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Circle 150 on reader service card

Single-wire pair multiplexes power and data for display

by Tommy N. Tyler
Powers Regulatory Co., Denver, Colo.

Using one decade counter per digit, this circuit multiplexes both power and data to a remote digital display over a single pair of wires. Implementing the circuit with a complementary-metal-oxide-semiconductor counter ensures the multiplexer draws only microwatts of power, a level that can be easily supplied by the circuit's power-storage element while data is being sent.

The arrangement required for a single digit is shown in (a). The circuit automatically initializes the display at zero on power up.

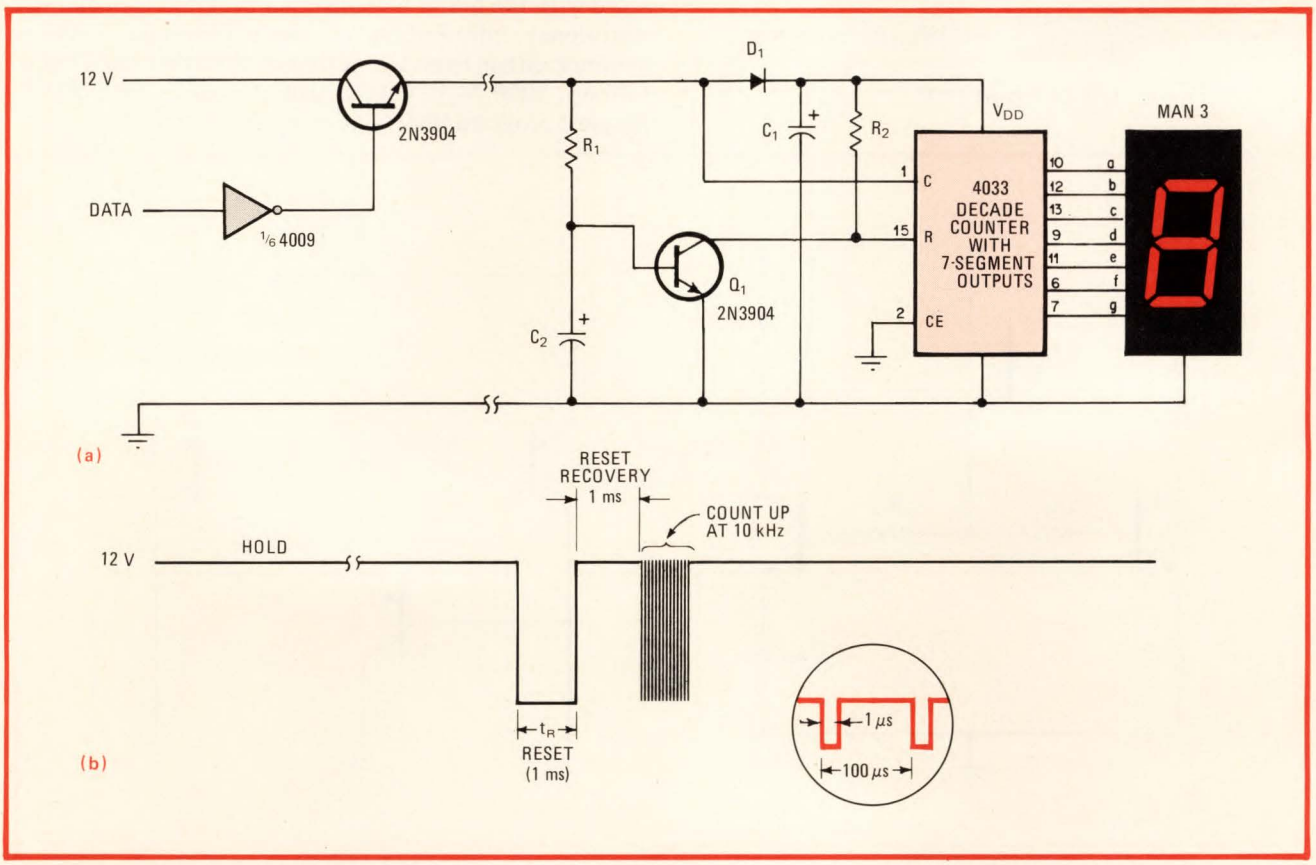
During the hold time (b), power is supplied to the 4033 counter via D_1, and C_1 charges up to the supply voltage. Following the hold interval, Q_1 turns off, allowing R_2 to pull the reset pin high, clearing the counter. The reset is accomplished by holding the line voltage low just long enough for C_2 to discharge and turn off Q_1. C_1 maintains power to the 4033 during this time.

After 1 millisecond, Q_1 turns on, and the number to be displayed is transmitted through the data line as a series of pulses with a 10-kilohertz burst frequency. These are sent directly to the counter's clock input. (Note that they are too narrow for the reset circuit to respond to.) Then the hold interval is repeated.

The display reading is updated by resetting the 4033 to zero and initiating a count again. By keeping the duty cycle of the data pulses very low, the display's supply voltage will remain essentially constant.

Multiple-digit displays require additional 4033s to be cascaded. With a 1-megahertz burst frequency, a four-digit display can be updated in 12 milliseconds, more than sufficient for ordinary viewing if the number of updates is at least two per second. Assuming four updates per second, the display will be steady 95% of the time. The 4033 will source 5 milliamperes per segment when operated at 9 volts, enough to produce fairly bright displays when MAN-3 devices are used. RCA application note ICAN-6733 provides extensive information on interfacing the 4033 chips with various displays. □

Engineer's notebook is a regular feature in *Electronics*. We invite readers to submit original design shortcuts, calculation aids, measurement and test techniques, and other ideas for saving engineering time or cost. We'll pay $50 for each item published.



Time share. Decade counter enables multiplexing of power and data lines with a single-wire pair (a). Power stored in C_1 during the first portion of the cycle energizes 4033 during the time data is sent. The hold-count timing cycle (b) clarifies operation.

HP-67/97 program performs current-mirror analysis

by Jim McDaniel
Precision Monolithics Inc., Santa Clara, Calif.

Analysis of the dc parameters of a current mirror—that is, a slaved current generator that tracks a reference—is difficult because the equations governing the circuit are nonlinear. Using an iterative technique, however, this HP-67/97 program permits easy solution of a complex 11-variable equation and enables the mirror, which is used extensively in monolithic operational amplifiers and in numerous discrete circuits, to be designed at either a fraction of the time (if charts and nomographs are used) or cost (if a computer is used).

The program allows design of the basic mirror circuit shown in the figure, where I_M, the mirrored current, can be made either equal to or some multiple of I_S, the reference current. This arrangement may be understood if the base-to-emitter junction of transistor Q_3 and resistors R_{B1}, R_{B2}, R_{E1}, and R_{E2} are replaced by shorts. Q_1 thus acts as a diode, and because its base and emitter leads are at the same potential as the corresponding leads of Q_2, I_M is made equal to I_S.

The loop equation describing the general circuit shown in the figure and analyzed by the program is:

$$\Delta V_{BE} + V_T \ln \frac{\beta_2(\beta_1+1)SI'}{(\beta_2+1)I_M} + I'[R_{E1}(\beta_1+1)+R_{B1}] - \frac{I_M}{\beta_2}[R_{E2}(\beta_2+1)+R_{B2}] = 0$$

where:

ΔV_{BE} = the measured mismatch between V_{BE1} and V_{BE2} when $I_{E1} = I_{E2}$

V_T = 0.026 volt at 298 K (25°C)

S = a scaling factor given by the ratio between Q_2's and Q_1's emitter area

β_i = the current gain of the i^{th} transistor.

I' is given by:

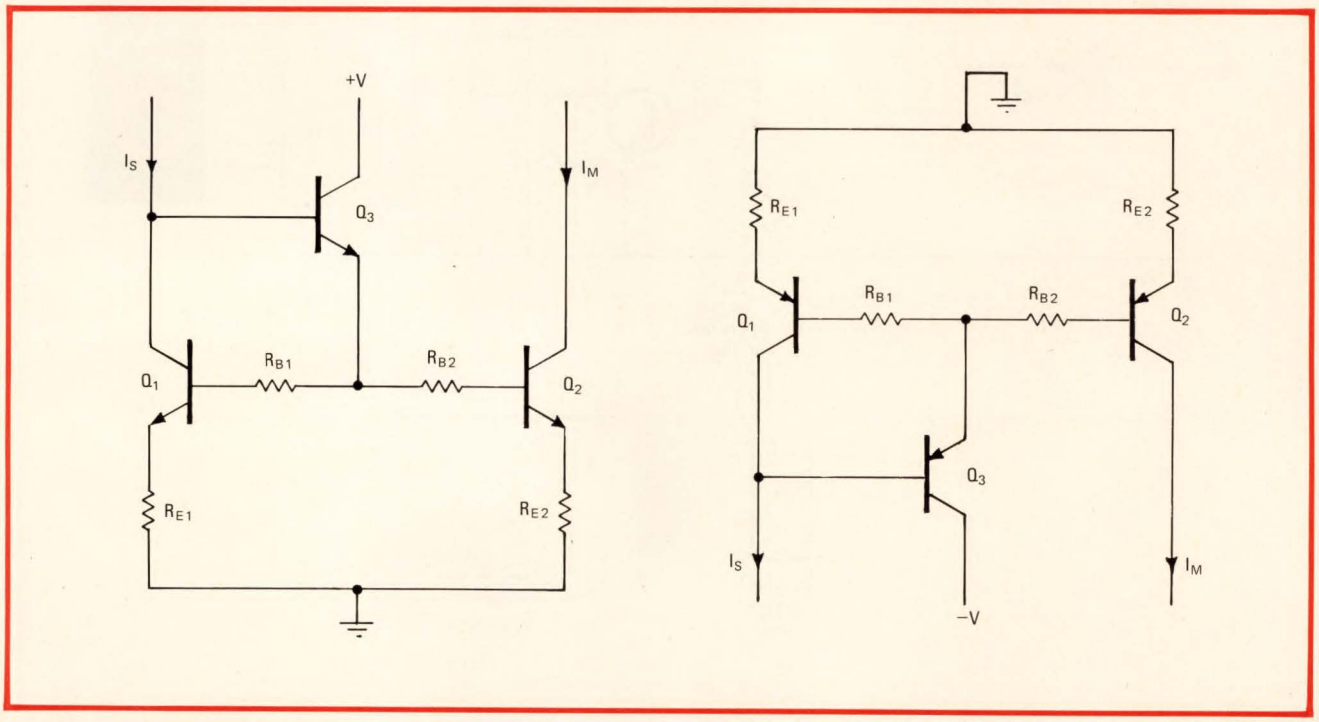
$$I' = \frac{I_S(\beta_3+1) - I_M/\beta_2}{\beta_1(\beta_3+1)+1}$$

Given any 10 parameters and an initial estimate of the remaining (unknown) quantity, the program determines the value of this last quantity by performing a Newton-Raphson iterative algorithm. In addition, it performs sensitivity analysis between any two parameters.

The program's usefulness may be seen in an example in which must be found, first, the value of R_{E2} that makes I_M = 25 microamperes when I_S = 250 μA at V_{BE} = 0, and when $\beta_1 = \beta_2 = \beta_3$ = 100 and S = 1; second, the sensitivity of I_M to a 1% change in R_{E2}; and third, the new value of I_M if V_{BE} = 1 millivolt.

Keying the appropriate quantities expressed in volts, amperes, or ohms, as the case may be, into their registers (note that $R_{E1} = R_{B1} = R_{B2} = 0$), and pressing f, b (see the instructions), yields R_{E2} = 2,371 Ω. Pressing 1, ENTER, 6, f, e, reveals that there is a −691.6% change in I_M for a 1% change in R_{E2}. Pressing 1, EEX, CHS, 3, E, B, indicates that, if ΔV_{BE} = 1 mV, I_M = 25.29 μA.

All parameters may be altered as functions of temperature with the aid of a companion program (not shown). Additional information on both programs may be obtained either from the author or the HP-67/97 Users' Library, 1000 N. E. Circle Blvd., Corvallis, Ore. 97330. Request program library numbers 2000 and 2001. □



Tracking. Program analyzes standard pnp or npn current mirror quickly and accurately. Checks of circuit sensitivity between any two circuit parameters are also performed. Setting $\beta_3 = 0$ is permitted in order to reduce the circuit to the basic two-transistor mirror.

HP-97 PRINTER LISTING: CURRENT-MIRROR PROGRAM

001	*LBLA	048	P⇄S	095	×	142	+
002	0	049	GSB3	096	RCLi	143	÷
003	GTO2	050	P⇄S	097	RND	144	X < 0?
004	*LBLB	051	STO2	098	X⇄Y	145	GTO5
005	1	052	RCL1	099	ST-i	146	LN
006	GTO2	053	RCL0	100	X⇄Y	147	RCL9
007	*LBLC	054	P⇄S	101	RCLi	148	×
008	2	055	X⇄I	102	RND	149	RCL4
009	F3?	056	X⇄Y	103	PSE	150	+
010	F3?	057	ST-i	104	−	151	RCL5
011	GTO2	058	X⇄Y	105	X = 0?	152	RI
012	R↓	059	STOI	106	GTO3	153	×
013	STO2	060	GSB3	107	RCLi	154	RCL7
014	STOA	061	P⇄S	108	RTN	155	+
015	STOB	062	RCL2	109	R/S	156	RCLE
016	RTN	063	P⇄S	110	R/S	157	×
017	*LBLD	064	%CH	111	R/S	158	+
018	3	065	RTN	112	*LBL4	159	RCL2
019	GTO2	066	*LBL1	113	RCLA	160	1
020	*LBLE	067	R↓	114	1	161	+
021	4	068	STOi	115	+	162	RCL6
022	GTO2	069	RTN	116	RCL0	163	×
023	*LBLa	070	*LBL2	117	RCLB	164	RCL8
024	5	071	STOI	118	1	165	+
025	GTO2	072	F3?	119	+	166	RCL1
028	*LBLb	073	GTO1	120	STOE	167	×
027	6	074	GSB6	121	×	168	RCL2
028	GTO2	075	*LBL3	122	RCL1	169	÷
029	*LBLc	076	GSB4	123	RCL2	170	−
030	7	077	STOD	124	÷	171	RTN
031	GTO2	078	RCLi	125	−	172	*LBL5
032	*LBLd	079	EEX	126	RCLA	173	RCLi
033	8	080	CHS	127	RCLE	174	PRTX
034	GTO2	081	4	128	×	175	GTO5
035	*LBLe	082	×	129	1	176	*LBL6
036	STOI	083	X = 0?	130	+	177	RCL9
037	RCLi	084	LSTX	131	÷	178	X = 0?
038	1	085	STOC	132	STOE	179	RTN
039	%	086	ST + i	133	×	180	·
040	ST + i	087	GSB4	134	RCL3	181	0
041	P⇄S	088	RCLD	135	×	182	2
042	STO1	089	−	136	RCL2	183	6
043	R↓	090	RCLC	137	×	184	STO9
044	R↓	091	ST-i	138	RCL1	185	RTN
045	STO0	092	÷	139	÷		
046	R↓	093	1/X	140	RCL2		
047	STOI	094	RCLD	141	1		

Registers	
R_0	I_S
R_1	I_M
R_2	β_2
R_3	S
R_4	V_{BE}
R_5	R_{E1}
R_6	R_{E2}
R_7	R_{B1}
R_8	R_{B2}
R_9	V_T

Labels			
A	I_S	a	R_{E1}
B	I_M	b	R_{E2}
C	B	c	R_{B1}
D	S	d	R_{B2}
E	V_{BE}	e	S

Instructions

- Key in program
- Enter design parameters: reference current, mirror current, current gain of the transistors, emitter scaling factor, mismatch (voltage difference) between the emitters of transistors Q_1 and Q_2, and the circuit's component values:

  (I_S), A, (I_M), B, (β_2), C, (S), D, (ΔV_{BE}), E, (R_{E1}), f, a, (R_{E2}), f, b, (R_{B1}), f, c, (R_{B2}), f, d

  Be sure that S ≠ 0 and that an initial estimate of the variable to be found is also entered.
  If the β of transistors Q_1 and Q_3 differ from that of Q_2, enter their values: (β_1), 20, fGSB, 2, (β_3), 21, fGSB, 2
- Press the label key corresponding to the variable to be found:

  f, label

  A flashing answer or a display of ERROR means the initial estimate is not sufficiently close to the actual answer.
  To solve for β_1 or β_3, enter register 20 or 21 respectively, then hCF, 3, fGSB, 2
- To find the percentage change in one variable (Y) due to a 1% change in another variable (X) enter the register number of the independent variable and call out the register number of the dependent variable:

  (X), ENTER, (Y), f, e

Engineer's newsletter

Resistor in base line reduces supply's downtime

When a standard regulator circuit's current-limiting capability is tested, the control transistor setting the current passed by the series-pass element is often the first device to be destroyed. But R. O. Deck of Palo Alto, Calif., notes that **the difficulties really stem from the delay imposed by the regulator's input resistor-capacitor network.** The network is intended to remove hash generated by the circuit's zener diode, but also prevents the control transistor from reacting quickly to a sudden rush of current through its base-emitter junction.

His solution is simple: place a resistor of about 1 kilohm in series with the control transistor's base lead, which is normally connected directly to the collector of the series-pass element. This will solve the problem with virtually no effect on the normal operation of the supply.

Low-Q inductors shrink size of passive filters

Mention the words "passive filters" to circuit designers and many will dismiss them as being too large and bulky. But they needn't be—filters using small, low-Q inductors can meet a great many applications with only a slight sacrifice in performance, says Marie L. Fuchs, senior filter design engineer for TRW/UTC Transformers, New York City, although larger inductors must still be used for filters requiring extremely flat passbands and sharp cutoffs. But the low-Q inductors can miniaturize filters to less than 2 inches square and ½ in. high. She ran tests to compare the response of standard low-pass Butterworth, Chebyshev, and Bessel filters (all having input and output impedances of 1000 ohms, and a Q of from 8 to 10 at a cutoff frequency of 1,000 hertz) to their corresponding ideal counterparts, and she found that for any given frequency, filter attenuation was within 2 dB and the phase response within 6°. Insertion-loss and time-delay characteristics suffered the greatest changes—only 1.2 dB (for a Bessel filter) and 70 μs (for a Chebyshev filter), respectively. **The low Q also had a somewhat beneficial effect on linearizing, or flattening, the phase angle and time-delay curves of the Butterworth and Chebyshev filters.** Obtain further data from Fuchs by writing her at TRW Inc., 150 Varick Street, New York City, N. Y. 10014.

Biasing the rectifier improves frequency response

The useful frequency range over which a precision rectifier operates can be improved by a factor of four by appropriately biasing the circuit, says Steven Woodward of Woodward Measuring Instruments Ltd. of Ontario, Canada. Begin with the well-known circuit in which an op amp's gain is determined by input and feedback resistors, with a diode connected between the junction of both resistors (anode) and the op amp output (cathode) and a second diode connected from the output (anode) to the free end of the feedback resistor. Then modify it so that slewing, and consequently response time, is reduced. The trick is done by placing two resistors in series, with one connected to the output of the op amp and the other to a negative supply voltage, and **reconnecting the first diode's cathode to the junction of these resistors.** The diodes should be fast-response types, such as 1N914. Typical values for the voltage-divider network are 470 kΩ for the resistor connected to the op amp and 12 kΩ for the resistor nearest the supply. **Vincent Biancomano**

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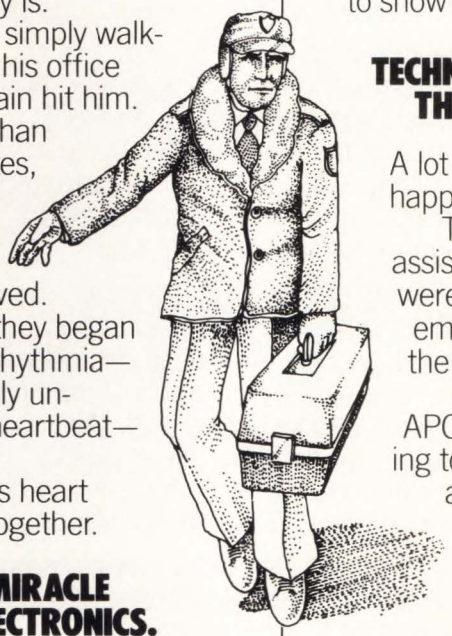

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THIS MAN BACK TO LIFE.

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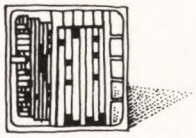

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GENERAL ELECTRIC

Meter resolves 60 electrons/second

4½-digit electrometer uses custom MOS front end to measure currents as low as 200 femtoamperes full scale

by Albert F. Shackil, Instrumentation Editor

Keithley Instruments has set the state of the art for current measurements with its model 642 electrometer, a 4½-digit instrument that directly measures voltage, current, and charge. The highly sensitive unit employs custom metal-oxide-semiconductor circuitry to replace the vibrating-reed modulator used in the input sections of supersensitive electrometers since 1947.

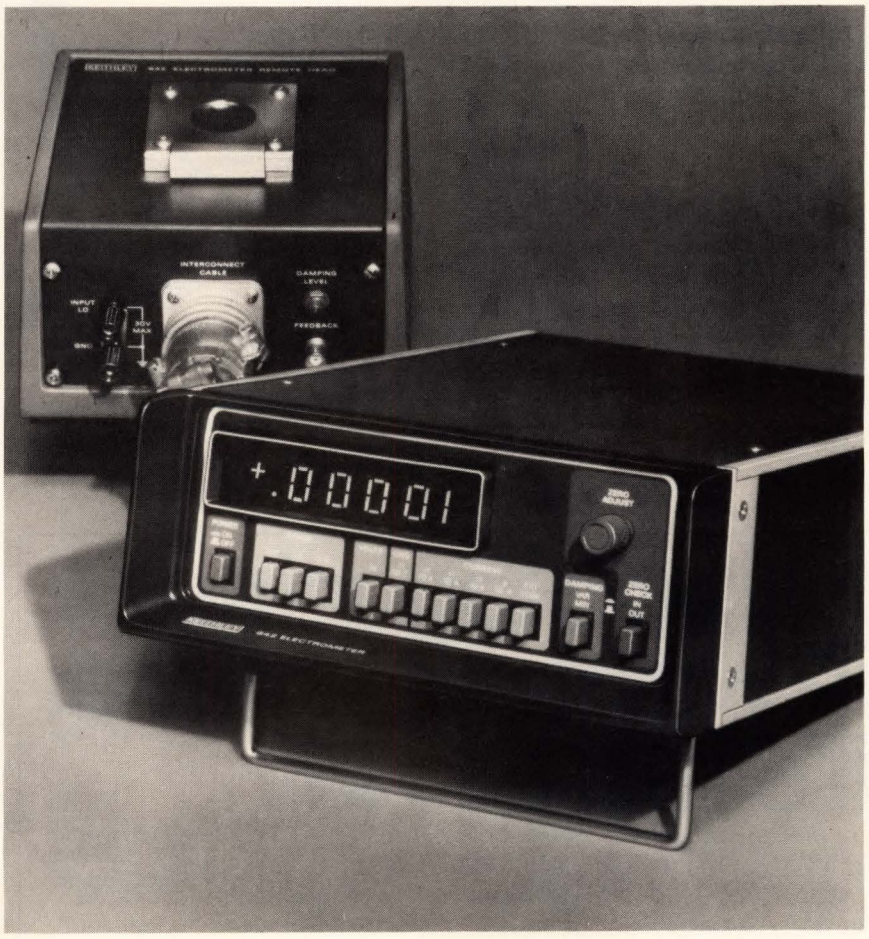
The 642 has three voltage ranges: 200 mV, 2 V, and 11 V full scale. For the voltage function, the input preamplifier is used in a noninverting configuration, which provides a very high input resistance—10^{16} Ω. Worst-case error for the voltmeter occurs on the 200-mV range, where it is 0.05% of reading plus three counts, exclusive of noise. The error figure is valid for six months for temperatures from 20° to 30°C. Noise is 10 μV rms (50 μV peak-to-peak).

For measuring charge and current, the preamplifier is configured as an inverting operational amplifier, which keeps the input at virtual ground and therefore imposes an extremely low voltage burden on the circuitry under test. Current-measuring ranges extend from 100 nA full scale down to 200 fA full scale. On this last range, the resolution is 10^{-17} A or 10 attoamperes (about 60 electrons/s). Maximum measurement uncertainty occurs on this lowest range: 1.5% of reading plus six counts. The figure holds for six months at 25° ± 1°C.

Under these same conditions, the model 642 can measure charge to within 0.3% of reading plus five counts. The charge-measuring ranges go from 10^{-10} down to 4×10^{-16} coulombs.

The electrometer consists of a remote head, a mainframe, and an interconnecting cable. The remote head contains the special MOS field-effect-transistor amplifier and feedback circuitry needed to implement all instrument functions. The head is intended to be located as close as possible to the circuit being monitored and can be rigidly connected, avoiding the current noise created by flexible cabling.

The mainframe front panel houses the push-button switches for measurement modes, range multipliers, and damping and zero-check controls. The damping control allows the selection of minimum or variable damping for the preamplifier's time constant. In the variable mode, the damping level is adjusted for the desired settling time using a trimmer located on the remote head. The damping control permits noise-bandwidth tradeoffs over a wide range;



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Three design systems of the future, with capabilities built-in to save electronics laboratory time. The Elite I, II & III eliminate conventional breadboarding problems, providing optimum circuit construction, adaptability and wide-ranging applications. New designs formerly taking days or weeks of engineering time can now be built, tested and finalized in hours. Without soldering—without special patch cords: just insert hook-up wire or component leads into specially designed component sockets (SK-10®) and pin jacks. No soldering means no waste. Thousands of these versatile systems are being used internationally for constructing, testing, trouble-shooting and optimizing all types of analog and digital circuitry. Join the Elite. Step into "Time Machines" of the future. Send for our free "Bugworks®" catalog.

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TM

Circle 160 on reader service card

If this magazine is worth your time, it's worth 58¢.

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this capability is attributable to the direct-coupled arrangement of the MOS FET preamp, which has a single predominant time constant. Thus second order system problems, like overdamping or ringing, characteristic of electrometers using vibrating-reed devices are eliminated.

The zero-check control minimizes charge transfer, which causes erroneous charge measurements. The control not only compensates for residual charge transfer, but also allows for periodic readjustment of offset charges due to aging. The charge error of the 642 due to actuation of zero checking is typically less than 10^{-14} C.

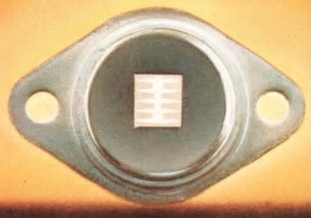
Ionization. The occurrence of current pulses caused by ionized particles due to cosmic or other radiation limits current measurements at very low levels. The magnitude and frequency of these pulses is determined by the volume of air surrounding the input terminal and the amount of radiation generated by the materials surrounding the input terminal. The unique design of the 642's remote-head input terminal minimizes the air volume and avoids the use of materials such as lead, which generate significant amounts of radioactivity. The 642 produces only 15 self-generated alpha pulses per hour.

Several accessories are available for the model 642: the model 6421 desiccant paper refill; the model 6422 binary-coded-decimal output option; the model 6424 BNC input connector, for use in coarse setups with flexible cables; the model 6425 GR874 air-line input connector, which connects to a rigid air line for use at more sensitive current levels; the model 6426 sapphire-insulated test box, which mounts directly on the remote head and permits testing of components or assemblies to the maximum sensitivity of the 642; and the model 6428 battery adapter, which permits the 642 to be powered by an external 12-v battery.

The price of the model 642 is $3,395. Delivery time is 60 days.

Keithley Instruments Inc., 28775 Aurora Rd., Cleveland, Ohio 44139. Phone (216) 248-0400 [338]

Kilowatt MOSFET Transistors have arrived!



Today, the advanced characteristics of field effect transistors are available at power levels which previously only bipolar transistors could handle.

International Rectifier now produces the world's highest power MOSFET transistors in two versions: high current Type IRF100, rated at 16 amps/80 volts, $R_{D(ON)}$ 0.2 ohms max.; and high voltage Type IRF305 rated at 400 volts/5 amps, $R_{D(ON)}$ 1.0 ohms max.... both capable of switching well over a kilowatt.

IR Power MOSFETs simplify control circuitry because they can control kilowatts with micro-amperes. Second breakdown is banished. Switching is 10 times faster. Paralleling is simple. Temperature stability is superb.

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IOR

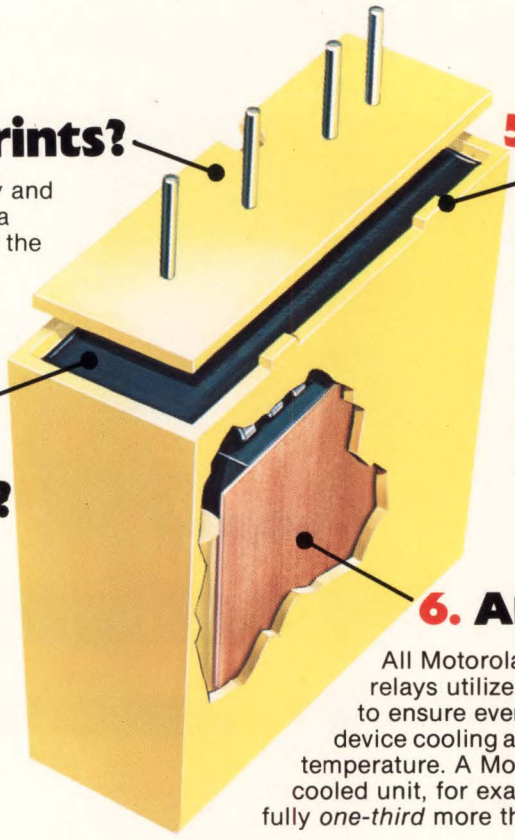
The people who put real power into MOSFETs!

Circle 161 on reader service card

15 Surefire ways Motorola SSRs

1. Does it have covered footprints?

Each Motorola solid-state relay and I/O module has covered feet—a cap fits neatly and snugly over the leads, preventing bowing of the terminal and ensuring dimensional consistency and positioning stability.

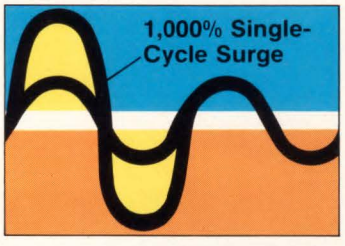


2. Is the potting good?

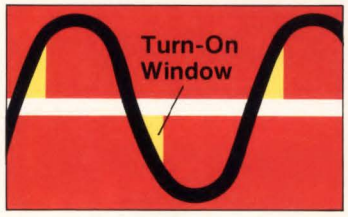
Ours is. It's a void-free, vibration- and moisture-resistant compound that's withstood billions of hours of rugged industrial and under-the-hood automotive environments . . . the most demanding of all.

3. Is there adequate surge?

Our units offer 1000% single-cycle surge ratings against faults, transients and current abuse. That's 2 to 3 times what others usually provide.



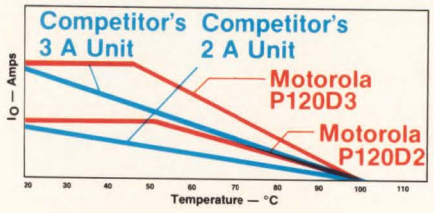
4. Is state-of-the-circuit-art used?



Our IDC5 has a special input circuit for wider input voltage windows to better control maximum current. The IAC5 has improved circuitry for dependable threshold at low AC inputs for better snap-action charactersitics. The OAC5 and PCB-mounted units have improved control of the zero crossing window, minimizing noise and keeping the environment clean.

5. Do the bases have standoffs?

Standoffs eliminate intimate contact between unit and board, reducing component thermal stress and preventing collection of contaminants.

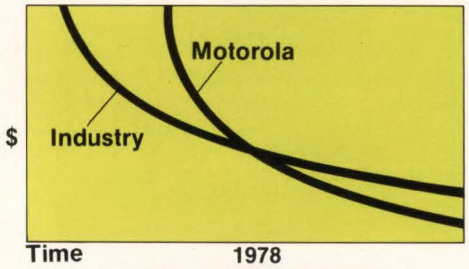


6. Are heat spreaders used?

All Motorola output and PC board relays utilize copper heat spreaders to ensure even thermal gradients, efficient device cooling and inherently higher performance at any temperature. A Motorola P120D3 board-mounted, free-air cooled unit, for example, furnishes 3 A @ 45°C capability, fully *one-third* more than a comparable unit *with* a heat sink.

7. Is it second sourced?

In the wild and wooly world of SSR and I/O module packaging, there's only one manufacturer whose footprints and case dimensions are second-sourced—ours. No double board layout, no production hangups,no line shutdowns with Motorola.



8. Is it cheaper?

We make our own semiconductors. We assemble our own units. We use full-time, factory-trained labor. We're noted for high volume. That means unbeatable savings and consistency in product quality.

to tell genuine & I/O modules:

4kV

9. Does it have high isolation?

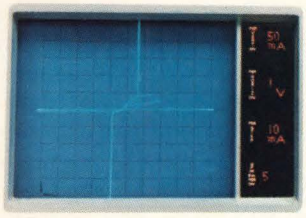
The high-quality, Motorola opto couplers employed are tested to 7.5 kV peak. This unmatched ruggedness, plus sufficient board spacing, makes our relays/modules able to withstand 4 kV, exceeding European VDE and IEC requirements of 3,750 V, as well as UL specs.

10. Is each component protected?

In addition to potting, Motorola uses a clear, conformal coating, up to now incorporated almost exclusively on MIL-I-46058C designs, over the entire PC board, except the triac, to prevent moisture intrusion. Inert, yet pliable, it raises reliability, increases VBR, acts as a thermal shock absorber and lowers costs.

11. Is it 100% tested?

Motorola SSRs and I/O modules are—for all key parameters: leakage, forward drop, breakdown, isolation and turn-on threshold. And, all units are tested at both board level and finished unit status to attain the highest degree of integrity and user confidence.



12. Can it take shake, rattle & roll?

Ours can. Completely potted units have shown ability to withstand MIL-spec type testing for accelerated impact, vibration, salt spray, thermal cycling life, etc.

13. Is it MPU-compatible?

Motorola's are. Use them with the M6800 Family microprocessors, other ICs or other solid-state relay control circuits demanding 5-V logic input.

14. Is the case flame-retardant?

UL flame-retardant VALOX 750 resin is rated 94V-0 at 0.030" and will not track under the most demanding high voltage application and high humidity environments, assuring long-term dependability. It also offers very low water absorption.

15. Are line improvements constant?

We'll soon be introducing timers in standard packages to the industry. . . something needed for some time . . . and a product addition only Motorola's dynamic, developing line could produce.

There are as many standards of quality in solid-state relays and I/O modules as there are sources. And it's hard to tell what you're getting just from specs, price and package contours.

Look inside. Product and company. What goes into each is what you'll be using, for better or worse.

Our standards of quality, reliability and performance are the highest in the industry . . . no-compromise yardsticks that make our products just a little bit better than others.

Get the best SSRs and I/O modules for the money. Motorola's. Write Motorola Subsystem Products, P.O. Box 20912, Phoenix, AZ 85036.

And, as they say, accept no substitutes.

MOTOROLA INC.

Circle 163 on reader service card

Packaging & production

ZIF connector orders closures

Edge-board unit's safety lock prevents contact closure on incorrectly positioned board

Most early applications of zero-insertion-force edge-board connectors were confined to standard card-file systems containing printed-circuit boards with large numbers of input/output connections. A new ZIF connector from AMP Inc. should widen the variety of potential applications, thanks to two novel features: sequential contact closing and the ability to accept cards through a side-entry slot.

Unlike earlier ZIF edge-board connectors, in which all contacts are closed to the board edge simultaneously, the new device has contacts that close in a predetermined sequence. When the actuating lever is moved, the ground contacts close first, then the power contacts, and finally the signal contacts. When the connector is opened, the sequence is reversed. This tends to prevent transient pulses generated by interruption of power or ground from coupling to the signal circuits.

The sequencing is done by a stainless-steel camming rod that actuates a special stepped cam follower. Because the connector guarantees a proper power-up sequence, the need for special ground interlocks is eliminated in most cases. Further circuit protection is provided by an integral safety lock, which prevents any contacts from closing unless the pc board is properly registered within the card slot.

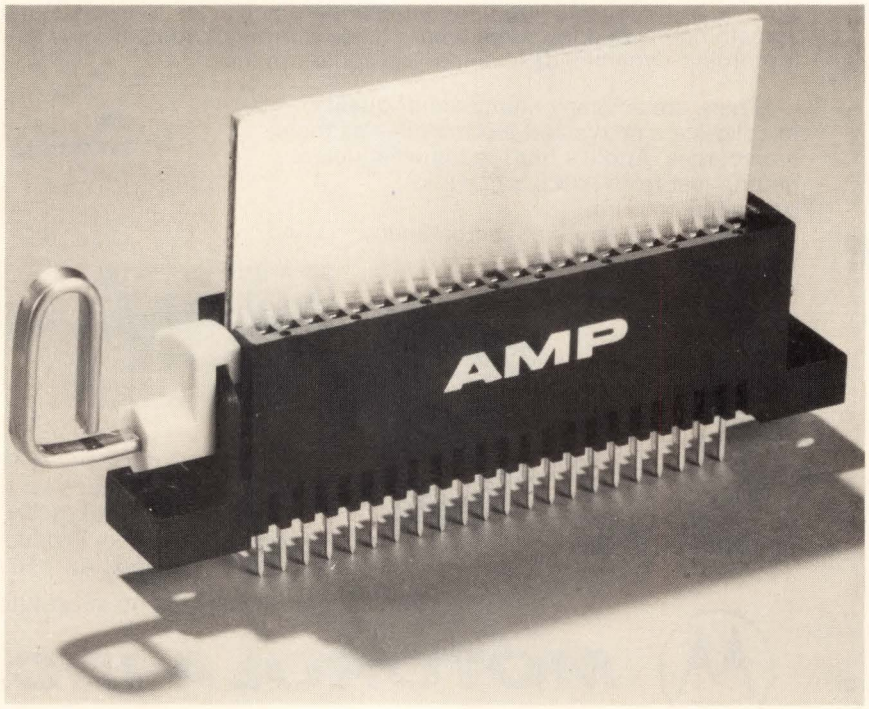
Another difference from earlier units is the side-entry feature. With the old-style connectors, each pc board was supported in the card cage by two card guides. The electrical connection was then made on a third edge of the board at the bottom of the cage. But the new connectors can act as both card guide and connector, which means that connections can be made to the two edges that are used for mechanical support. Not only does this permit more connections to the board, but it also leaves the bottom of the cage open for a freer air path to carry off the heat of the individual boards.

In addition, the side entry allows tandem mounting. A board may be slid through two connectors, both of which connect to the same edge of the card. A single lever can actuate and lock both connectors. Thus boards requiring two different supply voltages may be sequenced. Moreover, since the connectors slide on, all four edges of a board may be used for connection.

Double-sided or multilayer boards 0.054 to 0.070 inch thick with up to 130 contact pads (65 per side) on 0.100-in. center-line spacing, or 100 contact pads (50 per side) with 0.125-in. center lines, or 86 contact pads (43 per side) with 0.156-in. spacing can be used with this new connector family. Tandem arrangements with up to 240 contacts (120 per side) are possible.

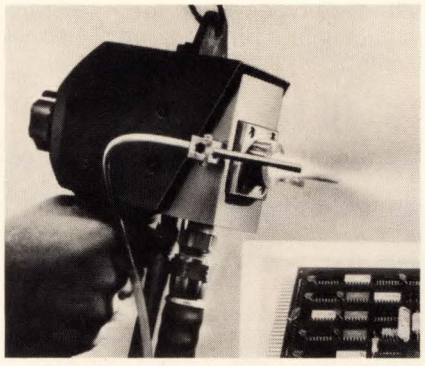
The connector's housing is molded from an Underwriters Laboratories–rated 94 V-0 glass-filled polyester. Its gold-over-nickel plated phosphor bronze contacts are rated at 3 A and have a life expectancy greater than 5,000 mating cycles. Operating temperature range is -55° to $+105^{\circ}$C. In large-volume production quantities the cost is approximately 5¢ per contact position. AMP is now in pilot production of the connector and expects to be ready for full production early next year.

AMP Inc., Harrisburg, Pa. 17105 [391]



Plasma spray system conformally coats boards

The Sealectrocote system protects printed-circuit boards and the devices on them with a conformal coat-



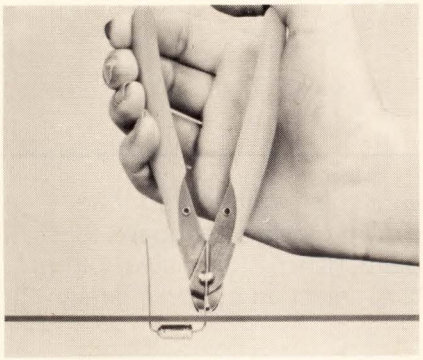
ing. Powdered polyurethane is sprayed at high velocity through a nitrogen plasma. The plasma melts the plastic so that it coalesces on the target surface in controlled thicknesses of 1 to 10 mils. The coating need not be oven-cured.

The system consists of a plasma spray gun, powder-flow control console, feeder, and power suply. It can also be used to apply acrylics, epoxies, polyesters, and other coating materials. The system is priced at $25,000 and delivery time is approximately four weeks. Ninety-day leases are available at a cost of $2,000 per month.

Sealectrocote Division, Sealectro Corp., Mamaroneck, N. Y. 10543. Phone Milan Robich at (914) 682-5600 [394]

Tool cuts leads flush and crimps in one step

Model 975-1 Micro-crimp simultaneously cuts and crimps leads of any length. The 1.5-oz tool is 5-in. long, flush-cuts lead wires of up to 14 AWG and comes with a lifetime guarantee



on its return spring. It costs $9.50.

Electronic Production Equipment Corp., P. O. Box 5238, Manchester N. H. 03108. Phone 1-800-258-3583 [396]

TM-500 dreamers can breadboard to reality

For years, the TM-500 series of modular instrumentation has sparked the engineering imagination. For every new module introduced, test personnel would dream up at least a dozen more they would like to have. Now the PI-910 lets them turn such dreams into reality.

Designed for compatibility with that series' power module, the breadboard-prototyping unit can accommodate sockets for any dual in-line packaged devices, so long as those sockets have pin spacings between 0.1 by 0.35 in. and 0.1 by 0.6 in. A maximum of 39 16-pin wrapped-wire sockets can be accommodated. For each pin position there are two extra holes for components.

Furthermore, the PI-910 comes with a +5-v, 1-A supply and ±15-v, 350-mA supplies. The printed-circuit board is arranged so that users can add an adjustable −5-v supply, a pair of fixed supplies and rectifying and filtering components for the power modules's 25-v ac power.

The plug-in breadboard has a prepunched subpanel that can hold five BNC-type connectors, 16 toggle switches, and four potentiometers. In single quantities, it sells for $135.

Pulse Instruments Co., 1536 W. 25th St., San Pedro, Calif. 90732 [393]

Crystal-withdrawal system is affordable alternative

Instead of building their own equipment, crystal growers now have the option of buying a pair of crystal-withdrawal systems at affordable prices. The version with an 8.5-in. stroke is priced at about $4,500, and the 14-in. version costs around $5,500. Both types pull crystals at rotational rates of 0 to 32 rpm and vertical rates of 0.01 to 1.8 in./h in vacuums as low as 20 torr. or under pressures of up to 20 atm.

So that the unit's shaft is precisely aligned, the mechanical housing is line-bored (both ends are bored in line after the housing is assembled). Limit switches are provided and internal components are sealed to prevent equipment damage. Delivery time is approximately eight weeks.

Varian Associates, Lexington Vacuum Division, 121 Hartwell Ave., Lexington, Mass. 02173 [395]

57 Surefire ways

. . . to get Motorola solid-state relays and I/O modules are shown in our authorized distributor and representative listing. Contact them about any of our high-quality Subsystem Products or contact Motorola Subsystems, P.O. Box 20912, Phoenix, AZ 85036, (602) 244-3103.

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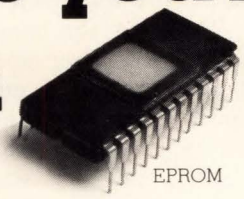
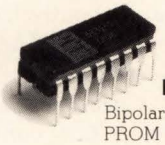
If you buy our competitors' programmers you'll be able to program  or  .

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Bipolar PROM

Never before has one programmer been able to do so much and make it so easy.

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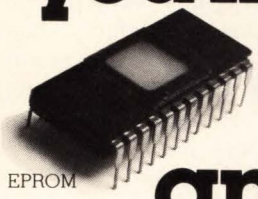
- Interfacing to peripherals, computers or microprocessor development systems is easy with Data I/O's exclusive dual function serial port or optional remote control software packages.
- Gang programming capability. Our new gang module will let you program up to eight MOS EPROMS at a time.

Buy our new System 19 and you'll be able to program


EPROM

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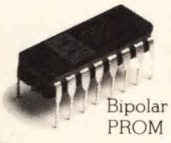
Bipolar PROM

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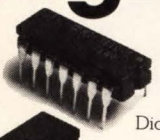
Diode Matrix

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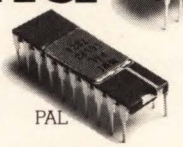
PAL

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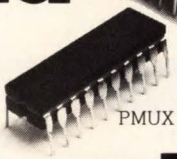
PMUX

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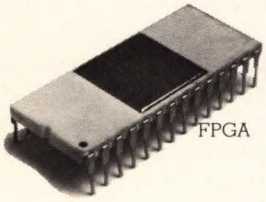
FPGA

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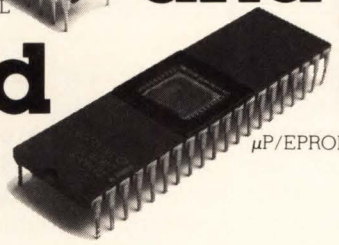
μP/EPROM

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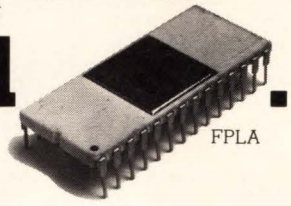
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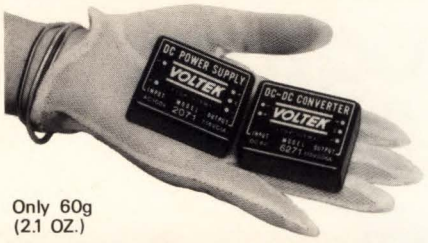

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Mini Switching Modules

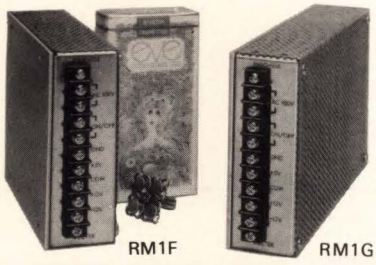
Model	Output	Size
2011	5V•0.5A	51W× 19H ×41Dmm (2"W×0.75"H ×1.63"D)
2031	12V•0.25A	
2061	±12V•0.1A	
2071	±15V•0.1A	

Source Voltage : 115Vac ±10%
Output Voltage Variation: ±5% (combined)

Mini DC~DC Converters

Model	Output	Size
6211	5V•250mA	51W× 19H ×41Dmm (2"W×0.75"H ×1.63"D)
6231	12V•150mA	
6261	±12V•50mA	
6271	±15V•50mA	

Source Voltage : dc5V or 12V or 24V
Output Voltage Variation: ±5% (combined)



RM1F RM1G

Triple Output Switchers

Model	Output
RM1F-104	+5V•2A, ±12V•0.2A
RM1F-106	+5V•2A, ±15V•0.2A
RM1G-104	+5V•3A, ±12V•0.3A
RM1G-106	+5V•3A, ±15V•0.3A

Source Voltage: 115Vac ±10%
Regulation(line): ±0.1%
Regulation(load): 0.5%
Ripple & Noise: 50mVpp
Overvoltage Protection: provided at +5V

VOLTEK CORP.

6-2-18, Nakanobu, Shinagawa-ku,
Tokyo, Japan 142

New products

Components

Trig multiplier has 0.1% error

Dc-coupled unit handles analog and digital inputs, produces quadrature outputs

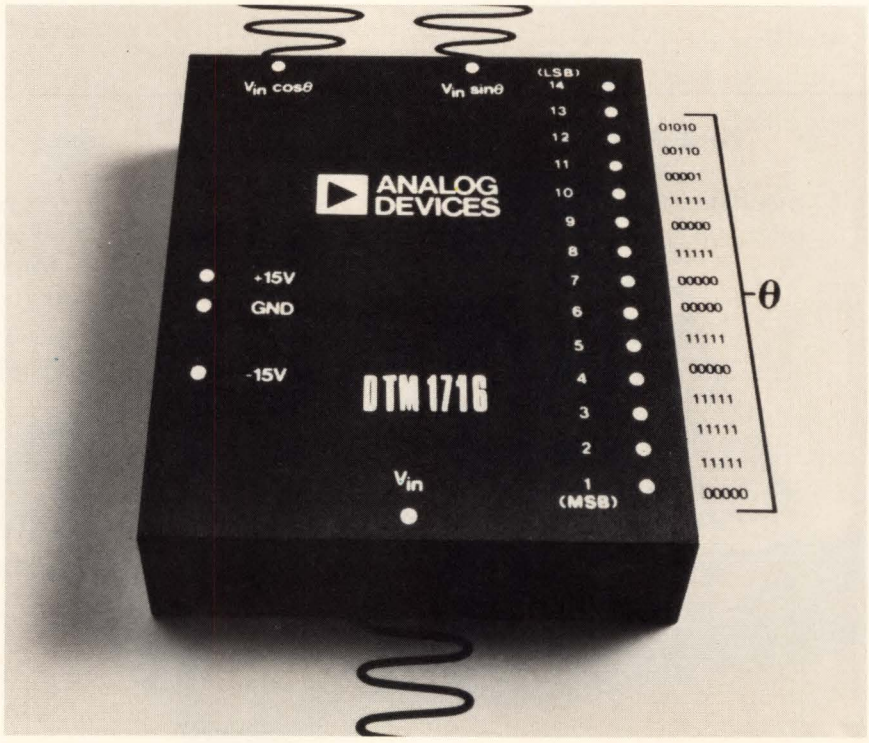
High accuracy is the key feature offered by a series of multiplying trigonometric digital-to-analog converters from Analog Devices Inc. Designed to help not only with digital-to-synchro conversion but also in signal processing and generation, the DTM 1716/1717 digital trigonometric multiplier takes two input signals, one analog and one digital, and generates a pair of quadrature outputs.

The digital input is a binary number representing an angle, θ; the analog input, V_{in}, can be of either polarity. From these inputs, the 1716/1717 generates two outputs: V_{in} sin θ and V_{in} cos θ. Amplitude error is no more than 0.1% of full scale, while angular error is a maximum of 3 arc minutes (approximately 0.012% of full scale). "The 0.1% transformation ratio compares with 7.0% now available in most sine/cosine generators," comments Edward H. Friedman, product line manager for synchro converters.

This accuracy will open up many applications for the 1716/1717 according to Friedman. "With torque receivers, the position of the shaft, set according to the ratio of sine to cosine, won't change if the power supply changes." In signal processing, the devices can be used to generate PPI (plan-position indicator) range rings for radar displays. "With the 1716, the sine and cosine waves are exactly 90° out of phase," says Friedman. "If they weren't, the circle on display would be oblong. Or if the ratio between them varied with the voltage, the rings would be wobbly," he adds. Other applications include power spectrum analysis.

The binary input for the 1716/1717 is compatible with standard transistor-transistor logic. For the 1716, the binary number is 14 bits long, with a least-significant bit of 1.3 arc minutes; for the 1717, 12 bits with 5.3 arc min.

The converters work from dc to



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Circle 169 on reader service card

8 kHz. Most synchro converters, Friedman points out, work on ac only. Because of the 1716/1717's dc coupling, he goes on, the units can be used as low-frequency function generators.

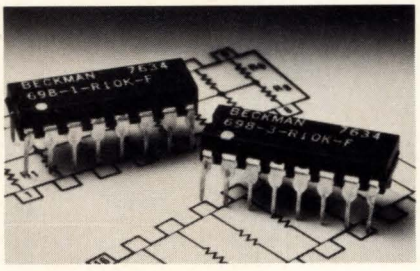
Two temperature versions are available for both devices: 0° to 70°C and −55° to +105°C. The latter version will also come specified to MIL STD 202. Both versions are housed in modules with dimensions of 3.125 by 2.625 by 0.4 in. Prices, for quantities of 25 to 99, are $247 for the 1717 and $269 for the 1716. Delivery time is approximately six weeks.

Analog Devices Inc., Route 1 Industrial Park, Norwood, Mass. 02062. Phone Edward Friedman at (617) 329-4700 [341]

DIP resistors vie with discretes in on-board price

Although resistors in dual in-line packages can speed assembly in large manufacturing operations, the precision-versus-on-board-cost curves have, until now, still favored discrete resistors. But the 698 and 699 series of metal-film resistor networks, which are packaged in 16-pin and 14-pin DIPs, respectively, are changing that. The series contain precisely matched elements that, on board, cost about the same as unmatched discretes.

The 698 series consists of units with 15 common- or 8 isolated-terminal resistors while DIPs of the 699 family contain 13 common- or 7 isolated-terminal resistors. Both series come in versions with resistor-ratio and resistance tolerances between ±0.1% and ±1%, and the resistors have temperature coefficients of 50 ppm/°C. Over their full



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1978

New products

temperature range of −65° to +125°C, the networks are stable at a particular temperature to within 5 parts per million.

Both series are available with standard resistance values in the range from 100 Ω to 100 kΩ and individual DIPs can dissipate a total of 700 mW at 25°C. In quantities of 1,000, typical prices are 75¢ for a 698 isolated-terminal unit with ±1% resistor-ratio and resistance tolerance and $2.19 for a 699 common-terminal unit with ±0.1% resistor-ratio and resistance tolerance. DIPs in standard resistance values are available from stock, and nonstandard values can be supplied on special order.

Beckman Instruments Inc., Advanced Electro-Products Division, 2500 Harbor Blvd., Fullerton, Calif. 92634. Phone (714) 871-4848 [342]

Little resistor puts up big resistance

Only 0.1 inch long, resistors of the 106 series come in standard values of 1 to 200,000 MΩ. With a 1-v biasing voltage, they exhibit a noise figure of 0.5 dB.

The tiny thick-film elements can work with maximum voltages of 60 v dc in the temperature range bounded by −200° and +150°C, have shunt capacitances of 0.1 pF, and are available with tolerances of −30, +300% and −90, +1000%, according to the maker.

In quantities of 1,000, a −30, +300% tolerance resistor is priced at 63¢. They are available from stock.

Eltec Instruments Inc., P. O. Box 9610, Daytona Beach, Fla. 32020. [344]

Operational amplifier is a swinging single

Following the trend toward single-supply operation, the model 9917 field-effect-transistor–input operational amplifier can operate from a positive 3-to-36-v supply, as well as from positive and negative power

sources. Furthermore, the output voltage can essentially swing from "rail to rail"—it approaches the maximum and minimum value of the supply to within 300 mV.

To reduce power consumption, the 9917 can be turned off by using an external transistor to drive it to a high-impedance state; this feature is particularly useful with three-state-bus systems.

The wideband device has a minimum gain-bandwidth product of 100 MHz and costs $57.50 in single quantities. Delivery is from stock.

Optical Electronics Inc., P. O. Box 11140, Tucson, Ariz. 85734. Phone Pete Suozzi at (602) 624-8358 [343]

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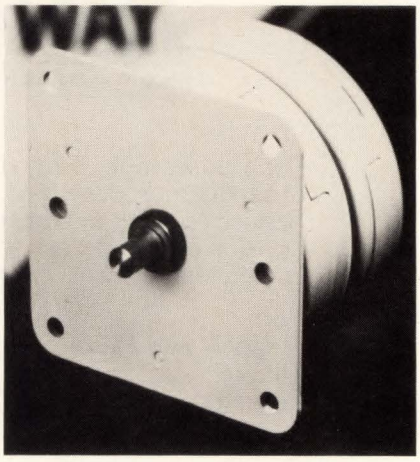
Reversible synchronous unit torques 21 oz-in. at 300 rpm

Considering its size—just 2.75 in. in diameter and 1.687 in. long—a member of the 81900 series packs quite a wallop. The electrically reversible synchronous motor provides 21 oz-in. of torque at a speed of 300 rpm.

The permanent-magnet motor can be ordered for 120-V or 24-V, 60-Hz



operation and consumes 17 W. In quantities of 100 and up, individual motors carry a low price of $15.65. Prototypes are available from stock and delivery time for production quantities is 10 to 12 weeks.

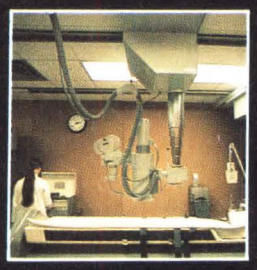
North American Philips Controls Corp., Chesire Industrial Park, Cheshire, Conn. 06410. Phone (203) 272-0301 [345]

High-value capacitance fits on 0.300-in. centers

Designed to optimize component density on printed-circuit boards, a ceramic capacitor from Varadyne can be inserted in standard 0.300-in. center-to-center holes. The capacitor has a value of 0.1 μF.

In lots of 10,000, the glass-encapsulated axial-leaded unit is priced at 15¢ apiece. Delivery time is eight to ten weeks.

Varadyne Industries Inc., 1520 Cloverfield Blvd., Santa Monica, Calif. 90404. Phone Ron Silverstein at (213) 829-2984 [346]



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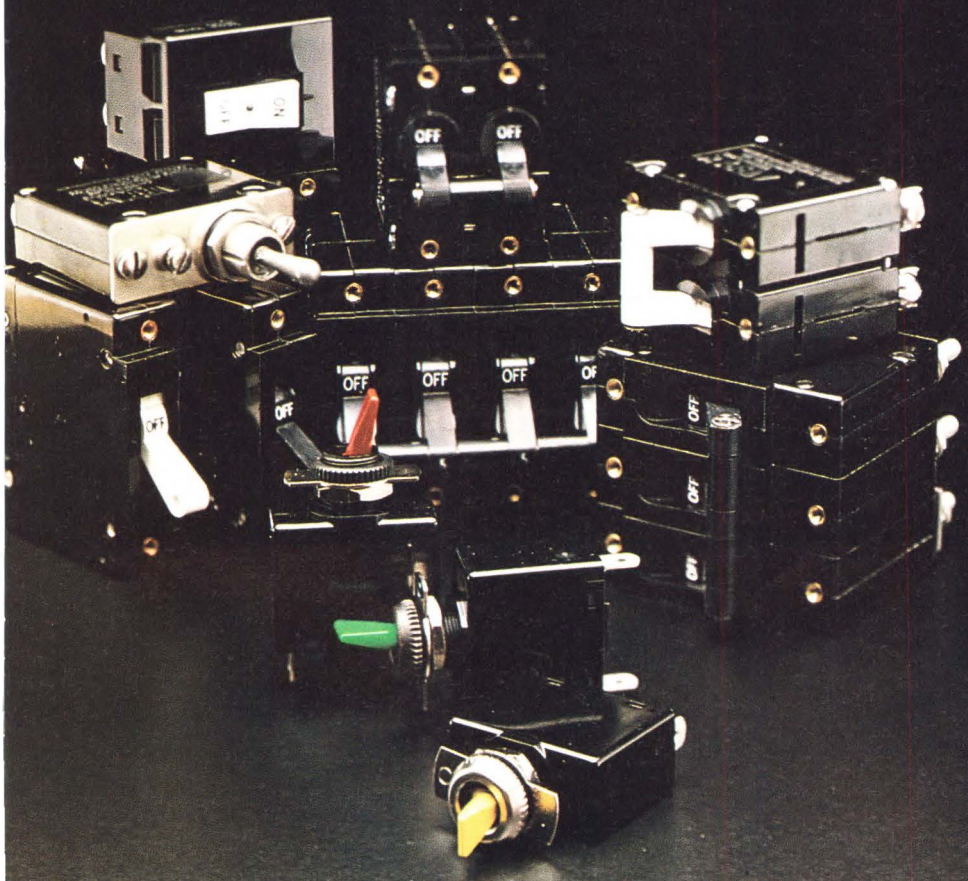

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Mark Levi
General Manager, Microcomputer Systems

Starplex™ Development System

"Right now, what's holding back new developments in microprocessing are the existing development systems.

The Starplex System is going to change all that.

And as of this moment, if you're in the business of designing or programming 8080 based products, this is the tool that can make your life infinitely less tedious.

So sophisticated is the Starplex System, it can virtually take you by the hand and walk you through its own operation.

Where other systems require scores of individually typed instructions, the Starplex System can do the same job at one stroke of a key.

Where other systems offer you blood, sweat, and repetition, the Starplex System offers HELP, PAUSE, EDIT, DEBUG, CONTINUE. To name a few of the unique functions on our keypad.

Where other systems leave you fumbling

	STARPLEX	INTEL	TEKTRONIX
SIMPLE KEYSTROKE CONTROLS	EDITOR SYSTEM UTILITIES	NONE	NONE
SYSTEM OPERATING MODES	FORMS OR COMMAND DRIVEN	COMMAND DRIVEN ONLY	COMMAND DRIVEN ONLY
CRT-ORIENTED EDITOR	YES	NO	NO
HIGH LEVEL LANGUAGES	2	2	NONE
ISE CAPABILITY	MULTI-PROCESSOR	SINGLE PROCESSOR	SINGLE PROCESSOR
PROM PROGRAMMER	INTE-GRATED OPTION	SEPARATE	SEPARATE
PRINTER	STANDARD	OPTIONAL	OPTIONAL
TOTAL PRICE (Exclusive of PROM Programmer and ISE)	$13,800	$21,870	$21,230

through thick manuals looking for escape clauses, the Starplex System guides you through your work path with a series of menus, prompts, lights, and audible signals.

And while some systems can communicate only in assembly, ours is fluent in BASIC and FORTRAN. Languages which can be loaded – as usual – with one keystroke.

Now others may have claimed their systems were "easy" before. But we've got the software to prove it. Which is why we do not hesitate to publish here a comparison chart which will show at a glance where things really stand.

The Starplex System is designed to be used with current and future National microprocessors, as well as BLC/SBC Series/80 microcomputers.

It's fully expandable, with four chassis slots allowing the addition of standard Series/80 boards. Plus a programming station which accepts optional personality boards for 2708, 2716, and bipolar PROMs.

Integrated into the Starplex package are five microprocessors, 64K bytes of memory, dual 256K byte floppy discs, a 1920 character CRT, a 50 CPS printer, and standard ASCII keyboard in addition to the special function keypads.

All the software you'll need is included in the package. A powerful operating system, macro assemblers, editor, debugger, and other key software modules.

We also offer the In-System Emulator (ISE), an extremely valuable option for hardware development. It works through an easily understood command interface. ISE uses its own memory for memory mapping – a time-saving feature which also allows true real-time debugging.

Because Starplex ISE incorporates symbolic debugging, you can debug code in the same assembly mnemonics in which it was written. And it's the only system emulator capable of debugging two microprocessors simultaneously in a multiprocessor system.

By any standard of comparison, the Starplex Development System represents a colossal leapfrog over the field in every category, save one: Price. And so, while others ask in excess of $20,000 for the privilege of unnecessary toil, our price is just $13,800. On the theory that not only is less more, but more should cost less.

We would jump at the chance to tell you the whole story in detail. Write or call me for a complete brochure on the Starplex Development System. Address your request to Mark Levi, General Manager, Microcomputer Systems, National Semiconductor Corporation, Drawer 34, 2900 Semonductor Drive, Santa Clara, California 95051. Or dial these toll-free numbers: 800-538-1866; 800-672-1811 in California."

Computer Products Group
National Semiconductor Corporation

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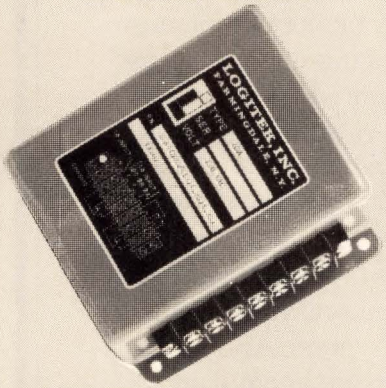
AC POWER PROBLEMS?

voltage
frequency } OK
phase } ?
current



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Microcomputers

P-MOS computers work at 6.5 V

Inexpensive four-bit single-chip devices can operate from −40° to +85°C

While 8- and 16-bit n-channel metal-oxide-semiconductor microprocessors have been getting most of the attention, 4-bit p-channel devices have been achieving impressive acceptance in the commercial and industrial marketplaces, chiefly as simple controllers. Designers at Rockwell International believe that these 4-bit devices would penetrate more deeply into the industrial area if they could work from lower voltages and over broader temperature ranges.

So five new one-chip 4-bit computers that the company is introducing have been designed to overcome these voltage and temperature limitations. Thus they enjoy increased potential for bit-oriented control applications.

According to Roger Helmick, product manager for microcomputer controls, the new devices require less than 15 mW at 8.5 V and can operate over the range from 6.5 to 11 V. Furthermore, the industrial versions will work from −40° to +85°C.

"They are especially desirable where low-cost battery operation as the primary or back-up power source is required; where power consumption or heat dissipation are considerations; or where portability is required," he maintains. Moreover, the new units will appeal to electronic toy manufacturers, which have been major customers in the past, he says. "With the new devices, a toy could run for 50 to 60 hours instead of 20" before the battery goes.

Now rolling out in large quantities are the MM77L and MM78L, which are arriving a few months behind the MM76L and MM76EL. The latter two units are already being shipped to several high-volume users said to be in the appliance field. The differences among these four devices are in their memory sizes.

The MM76L and MM76EL have 640 and 1,024 words of read-only memory for program storage, respectively; for the MM77L and MM78L, the respective capacities are 1,536 and 2,048 words. Random-access memory for data storage is 48 words for both MM76 computers, 96 words for the MM77L, and 128 words for the MM78L.

All of the improved 4-bit devices are software-compatible with previous higher-voltage counterparts in the Rockwell PPS 4/1 family, notes Helmick. They come in standard 40-pin dual in-line packages. Other features include serial input/output capability for parallel processing, two interrupt-request lines, compatibility with both transistor-transistor and complementary-metal-oxide-semiconductor logic, six working registers, 31 I/O ports, and a 50-instruction set.

The final chip in the set, which will be ready in mid 1979, is called the MM78ADL and will have an 8-bit analog-to-digital converter in addition to expanded input/output capability.

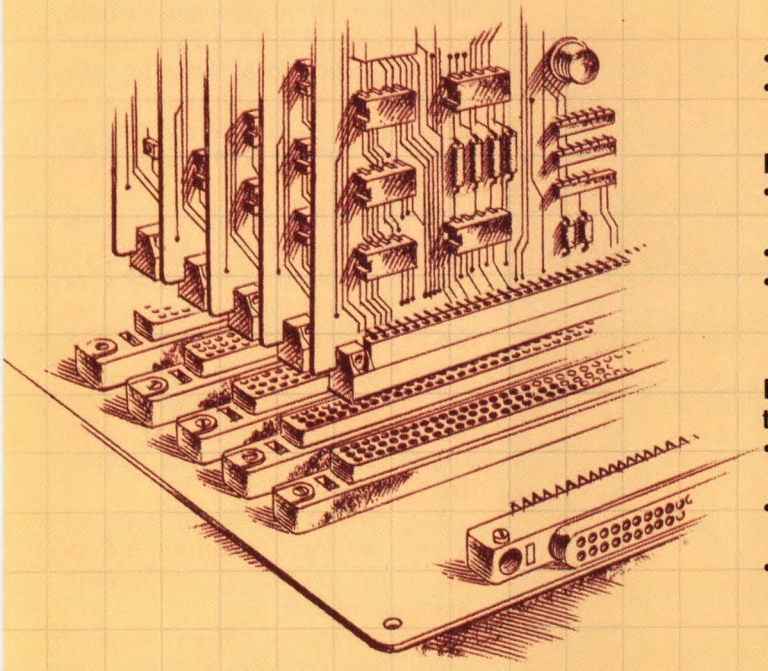
In pricing, the Rockwell policy is "to keep adding features rather than to make them cheaper," says Helmick. Depending upon quantity, the new units run from $3 to $5 each—about the level of the earlier PPS 4/1 family members.

Rockwell International Corp., Microelectronic Devices Division, 3310 Miraloma Ave., P. O. Box 3669, Anaheim, Calif. 92803. Phone (714) 632-3824 [371]

Board lets users develop TM990 software cheaply

The TM990/302 is an assembled, tested module for developing software for the 9900 family of microprocessors, either in assembly language or in the recently introduced Power Basic. Bus-compatible with other members of the TM990 fami-

PCB Simplicity with Bendix Brush Connectors.



Bendix Brush Connectors can streamline your printed circuit board designs. They don't require the extra board support necessary with conventional, higher mating force connectors and they eliminate the need for secondary actuation systems or procedures used with zero-insertion force connectors. Here's how:

Bendix Brush Connectors increase circuit count per board.

- Reduce number of boards by allowing more circuits per board.
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Bendix Brush Connectors reduce mating force 70% to 90%.

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- Extended mechanical life. Up to 20,000 mates/unmates.
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Bendix Brush Connectors—a broad product line.

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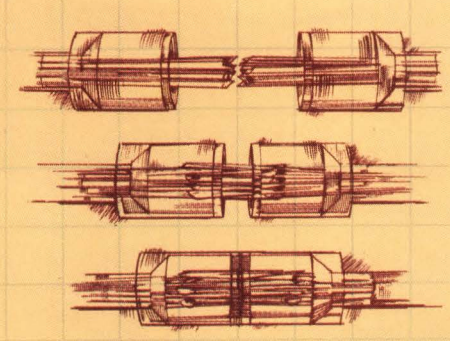

For full information, call (607) 563-5302, or write The Bendix Corporation, Electrical Components Division, Sidney, New York 13838.

Bendix

We speak connectors.

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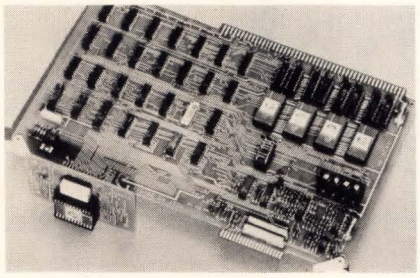

ly, the 302 can be used with either the TM990/100M or the 101M to form a complete, low-cost software development system.

The board provides storage for 2,048 16-bit words in static random-access memory, 4 kilowords in erasable programmable read-only memory (or preprogrammed ROM), and dual audio-cassette interfaces for offboard mass storage. In addition, it includes the hardware required for EPROM programming.

A text editor, symbolic assembler, debug package, relocating loader, and EPROM programmer reside in the board's EPROM, as does EIA interface software to link the unit with a TI990/4 or /10 minicomputer. With the appropriate personality card, the EPROM programmer provides the capability to verify erasure of and to program, read, and verify EPROMs such as the 2708, 2716, 2508, 2516, 2532, and 9940.

To power the system, a user needs supply voltages of ±12 and +5 v. In addition, 30 to 52 v is needed for EPROM programming. These voltages can be obtained from a TM990/518 power supply. The supply, the 302, and either of the microcomputers can be installed in a TM990/500, 510, or 520 (2-, 4-, or 8-slot, respectively) chassis.

The TM990/302 board is priced at $625 in single quantities and, in the same quantities, personality modules cost $60.

Texas Instruments Inc., Inquiry Answering Service, 8600 Commerce Park Dr., M/S 6404 (Attn: TM990/302), Houston, Texas 77036 [373]

Forethought. The only sure cure for buyer's remorse.

By the time you get all your electronics into the cabinet, get it sold and get it shipped, any weaknesses in the design will show up in spades.

If the levelling legs aren't properly reinforced, they can pop through the bottom under a full load.

If the seams aren't completely welded and sealed, they may begin to open after you install your equipment.

If the internal engineering isn't perfect, the unit may exhibit the Leaning Tower Effect by the time it gets to your customer.

If the external design isn't first class, your product won't have that crisp, professional look.

If the cabinet isn't a Zero Matrix IV, the design engineering probably won't protect you from all the problems you didn't think about.

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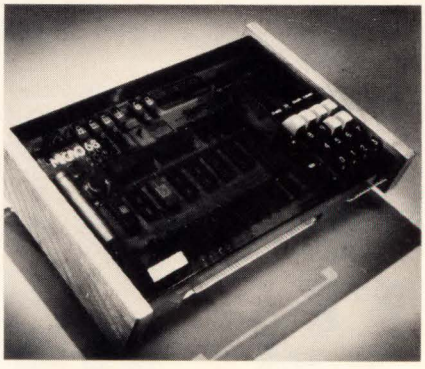
Teacher aids students by going to PROMs

Like its predecessor, the Micro-68, the 6800-based Micro-68 II comes neatly packaged with a 16-pushbutton hexadecimal keyboard, a 6-digit light-emitting diode display, and an integral power supply. The latest



A Place in the Rain

It rains here. Not as much as in many places, but more than in some. Out here you'll hear stories about rain. But better yet, you'll see what the rain means for our life. Dark forests on our mountain ranges. Fishing streams flowing down clear from the high lakes. Wildflowers, from alpine meadows to city woods. A clean metropolitan skyline on the Willamette River just minutes away. Yes, it rains here in Oregon. And it means life to us. We've found a place in the rain–we're Tektronix, a Fortune 500 leader in electronics test and measurement, and computer graphics. There's a quiet excitement to our enterprise. If you have experienced research, engineering, marketing or software development skills, write to Bill Eppick, Professional Placement. He'll answer your letter and send you a color print of this scene if you request it. No obligation.

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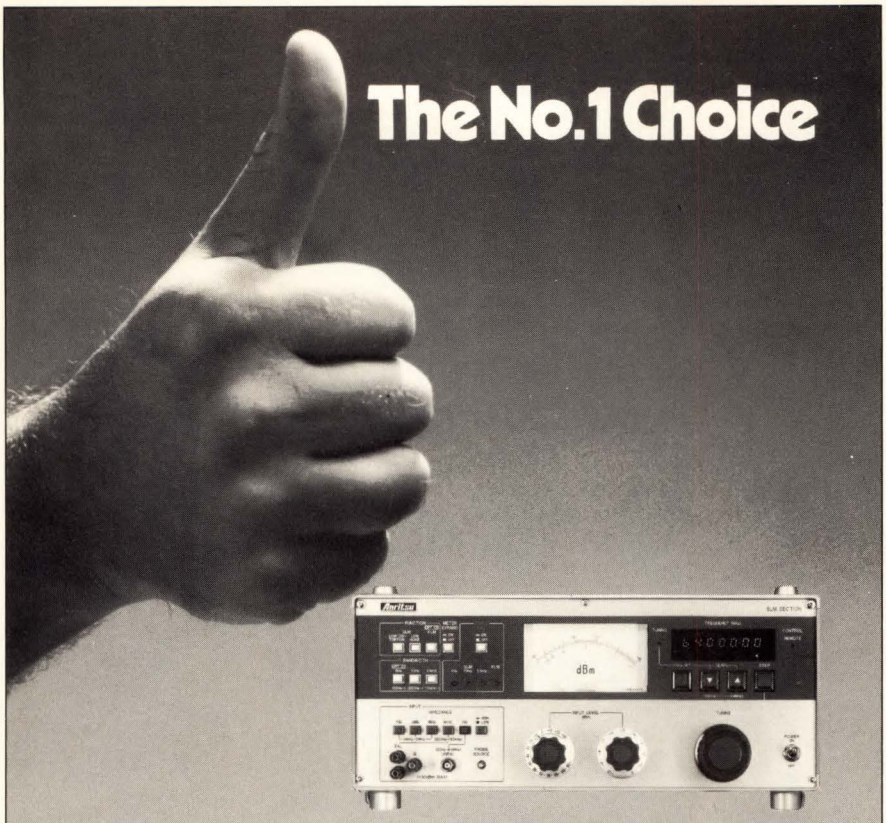

Anritsu's All-New Selective Level Meter ML38A

With a frequency range from 20 Hz to 6.4 MHz and frequency stability of $\leqq 1 \times 10^{-5}$, the new ML38A is bound to be your best choice in selective level meters. Its level measuring range of −120 dBm to +30 dBm (BW 70 Hz) is complemented by other standout features such as a 7-digit LED frequency display and a selection of three bandwidths—6 Hz (option 01), 70 Hz and 3.1 kHz.
Make the right choice—pick the ML38A.

Other Major Specifications

• Input impedance	75 Ω unbalanced 75 Ω, 135 Ω, 150 Ω, 600 Ω balanced
• Intrinsic distortion attenuation	≧68 dB (f: ≧2 kHz) ≧60 dB (f: 200 Hz to 2 kHz) ≧55 dB (f: <200 Hz)
• Power requirements	100V ±10%, 50/60 Hz, ≦50 VA
• Dimensions	195 (H) x 426 (W) x 350 (D) mm
• Weight	≦19 kg

For comprehensive literature on Anritsu's Selective Level Meter, contact—

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microcomputing teaching aid, too, has a 512-word read-only memory containing the routines needed to load, inspect, edit, and execute programs and to insert the breakpoints needed for debugging.

What the new model touts is its ability to accept 2 kilobytes of erasable programmable read-only memory. With this capability, users can develop their own operating programs and alter them at will.

Designed as an instructional and prototyping unit, the Micro-68 II can be purchased without a 2716 PROM for $615. For $40 more, it comes with a programmed PROM containing memory-test, self-test, and cathode-ray-tube monitoring programs. The unit is available from stock and arrives with complete documentation and an instruction course.

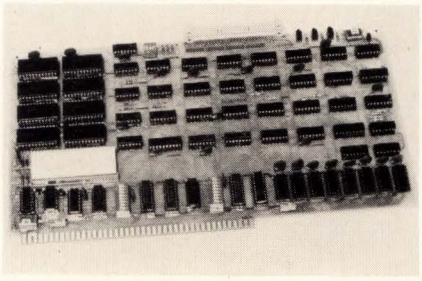
Electronic Product Associates Inc., 1157 Vega St., San Diego, Calif. 92110. Phone Chuck Bennett at (714) 276-8911 [376]

Board formats hard disks, can control four drives

Microsystem designers who need 40 megabytes of on-line storage can now turn their hard-disk control and formatting problems over to a single board, the HDC 1880. The microprocessor-controlled board can interface a Multibused system with front- or top-loading drives in the Diablo, Coelus, and Wangco families, among others.

The unit can control up to four drives, each with a fixed disk and a removable 5440-type cartridge pack. It provides direct memory access, expanded 20-bit addressing, and soft-error recovery.

Costing $1,495 in original-equip-



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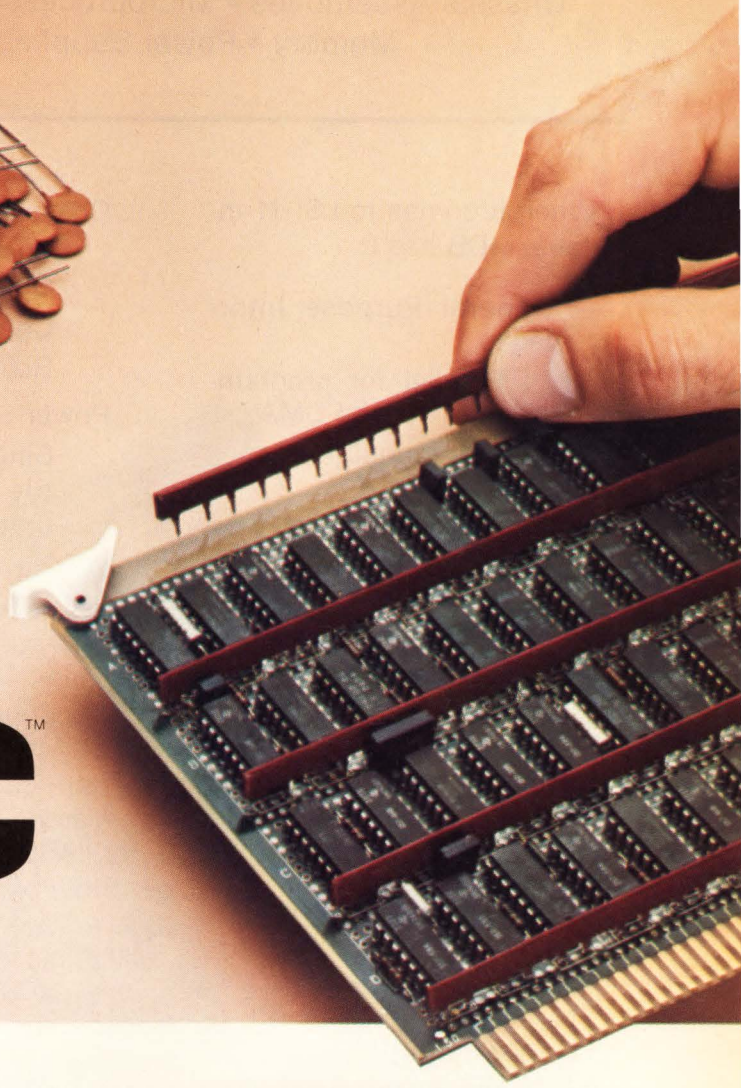

New, high capacitance Q/PAC power distribution elements are the exciting, revolutionary way to eliminate decoupling capacitors from printed circuit boards. Rugged Q/PAC elements are easy to install and increase system reliability through reduced part count.

Q/PAC elements are available in capacitance values up to 0.05μf per inch in lengths up to 16 inches. Configurations allow for either vertical mounting or horizontal installation under DIP packages.

Q/PAC elements eliminate the need for on board power traces and extra board layers. They maximize packaging density and minimize signal interconnection problems.

Q/PAC elements feature a low dissipation factor, low inductance and low impedance.

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  - Read-only modules (without memory)
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MDB interface products always equal or exceed the host manufacturer's specifications and performance for a similar interface. MDB interfaces are completely software transparent to the host computer. MDB products are competitively priced, delivery is 14 days ARO or sooner.

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MDB also supplies interface modules for PDP*-11, Data General, Interdata and IBM Series/1 computers. Product literature kits are complete with pricing.

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Circle 257 for LSI-11; 259 for PDP-11; 258 for DG; 260 for Interdata; 188 for IBM

New products

ment quantities, the HDC 1880 operates from a 5-v supply and is deliverable in 30 days.

Interphase Corp., 200 E. Spring Valley Rd., Richardson, Texas 75081. Phone (214) 238-0971 [377]

Multibus timekeeper knows when to interrupt host

Watching the flow of seconds, minutes, hours, days, and months for SBC and BLC systems, the Multibus-compatible MC1460 clock-calendar module can be powered by an external source when its host system is powered down. In addition, the card offers software-selectable interrupts that range from 10 μs to 24 h, a range that includes the 50-ms interrupt required by Intel's RMX-80 software.

The MC1460 can also generate power-failure interrupts using its onboard power monitor or in response to an external power-status signal. In single quantities, it sells for $425.

Canada Systems Inc., P. O. Box 516, La Canada, Calif. 91011. Phone (213) 790-7957 [375]

Multiuser operating system performs in real time

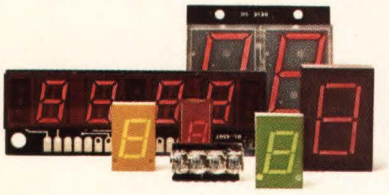
Writen for Z80-based systems, the Virtual Micro II is a multitasking operating system that lets its host respond in real time to multiple users. The software supports as many as four terminals and can handle them simultaneously.

The program resides in 32 kilobytes of random-access memory and works on systems configured with switchable 16-kilobyte banks of RAM, dual, IBM-compatible floppy-disk drives, and a real-time clock. It also provides management support for shared and private files.

Individual copies of the program can be purchased for $800 and licensing agreement are available.

Software & Systems Inc., 2801 Finley Rd., Downers Grove, Ill. 60515. Phone (312) 932-9320 [378]

WHAT A LIGHT SHOW!



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.27	DL-10A	single digit hybrid		4.65
.30	DL-700	single digit light pipe		1.50
.30	DL-300	single digit reflector		.90
.43	DL-7000	single digit filled reflector		1.30
.50.	DL-500	single digit reflector		.95

Character Size	Part Number (Series)	Product Description	Colors	Price*
.50	DL-520	two digit reflector		$1.25
.50	DL-4500	multi-digit array reflector		1.25
.510	DL-720	two digit light pipe		1.60
.630	DL-740	single digit light pipe		2.55
.80	DL-840	single digit reflector		1.75
.80	DL-6800	multi-digit array reflector		1.75
1.0	DL-3100	multi-digit array reflector		2.30

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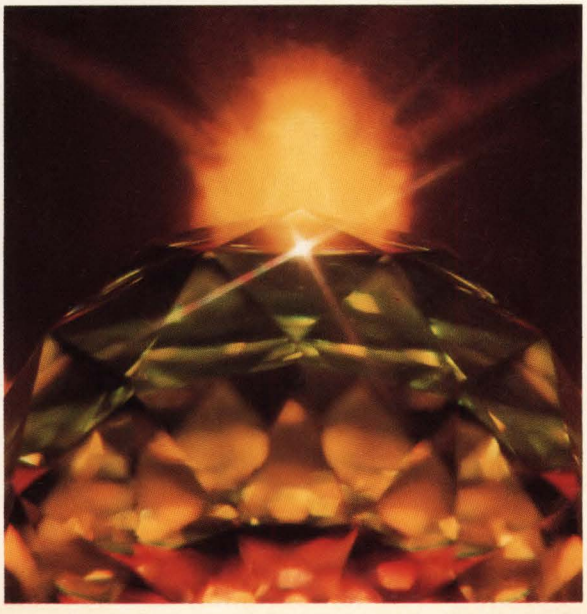

Circle 189 on reader service card

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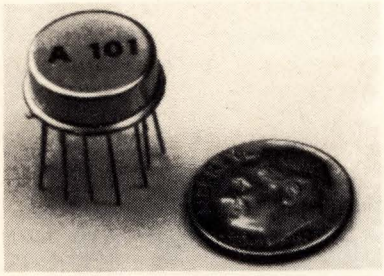

CHARGE SENSITIVE PREAMPLIFIER-DISCRIMINATOR

Model A-101 is a charge sensitive preamplifier-discriminator and pulse shaper developed especially for instrumentation employing photomultipliers, channel electron multipliers and other charge producing detectors in the pulse counting mode. Its small size (TO-8 package) allows mounting close to the collector of the multiplier. Power is typically 15 milliwatts and output interfaces directly with C-MOS and TTL logic. Input threshold and output pulse width are externally adjustable.

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Data acquisition

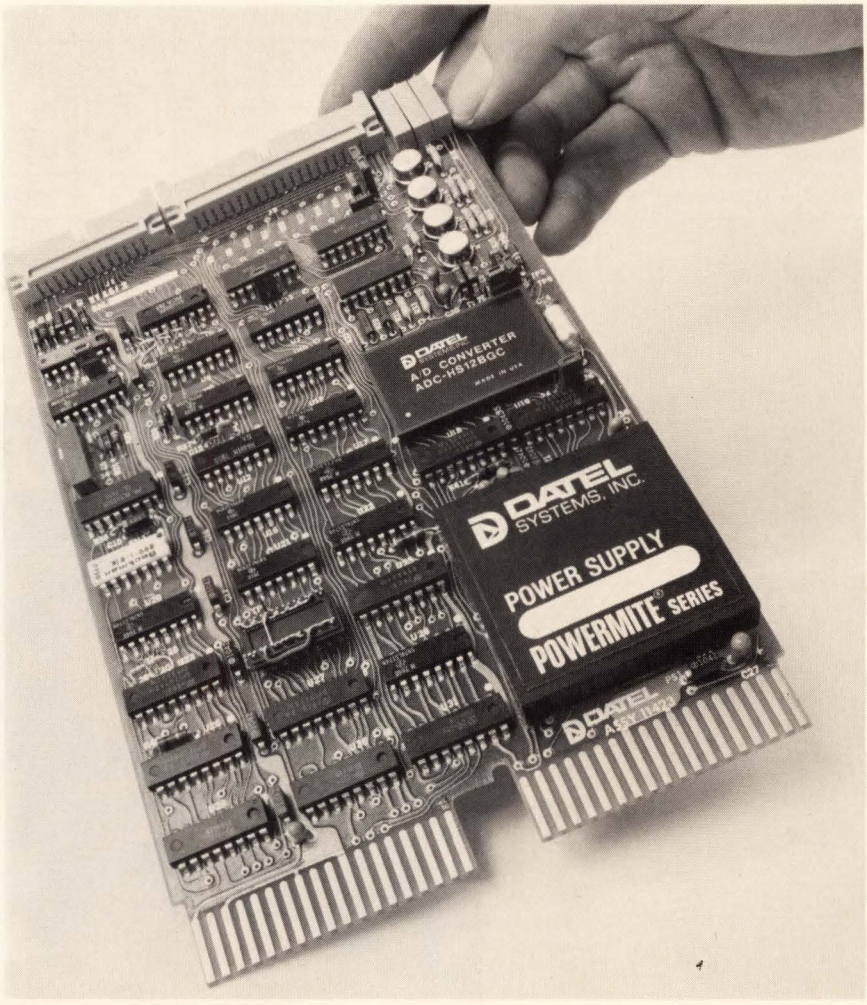
LSI-11/2 board sells for $595

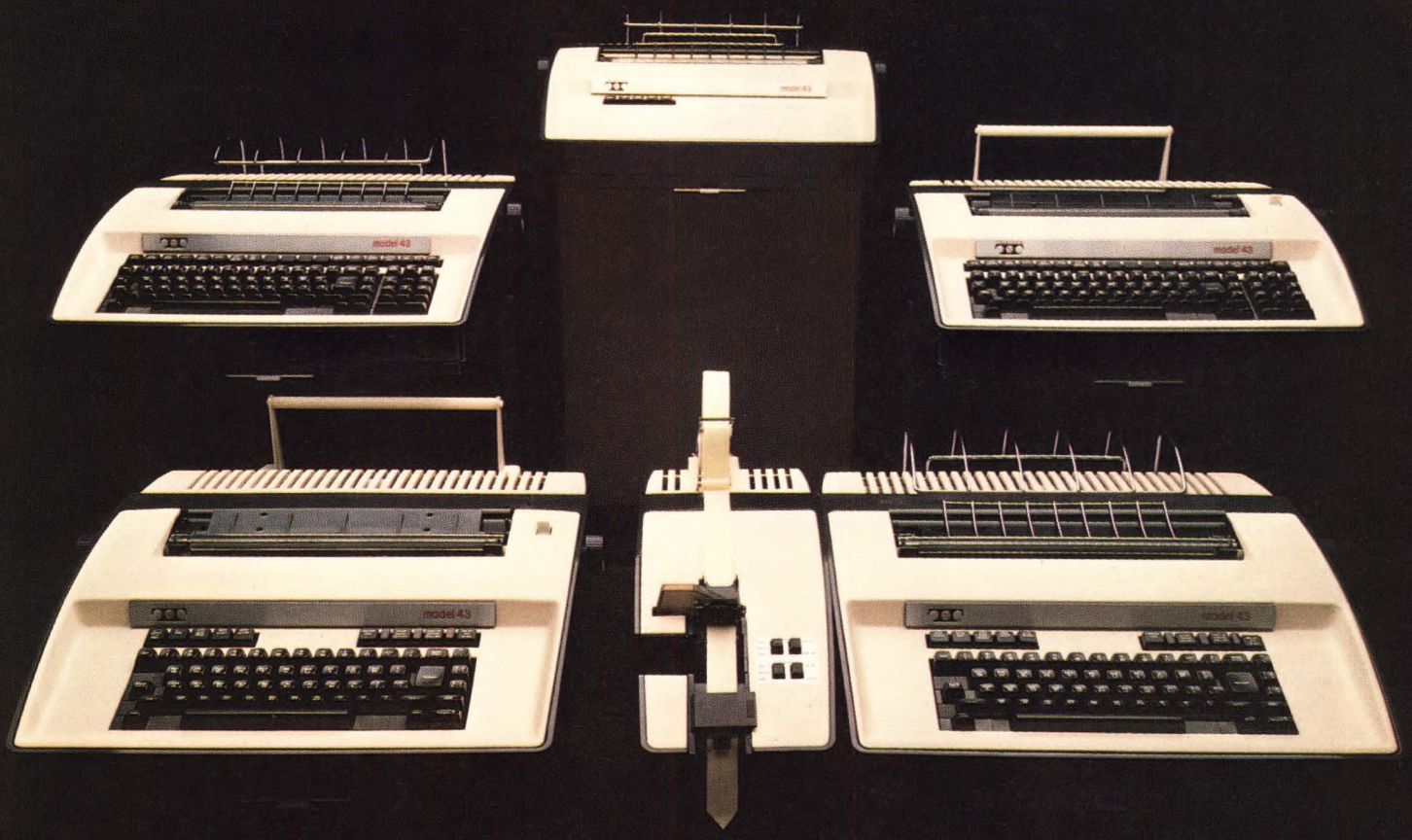
Data-acquisition subsystem includes programmable-gain amplifier, pacer clock

It's not the first analog-to-digital-converter subsystem designed to mate with Digital Equipment Corp.'s LSI-11/2 microcomputer, but engineers at Datel Systems Inc. believe that their ST-LSI2 includes the features most commonly asked for by industrial users and that the price is right.

Lawrence D. Copeland, product marketing manager for computer peripheral products, is not restricting the a-d board to applications in industrial data-acquisition, however. He notes it is suitable for programmable process controllers, automatic test equipment, laboratory and analytical equipment, and other uses.

"We've sold a lot of analog input boards for industrial applications of other microcomputers," Copeland observes, "and the most commonly asked-for feature is a programmable-gain amplifier." The ST-LSI2, which offers 16 single-ended channels (8 differential) on a single 8.5-by-5-inch board, incorporates a differential programmable-gain amplifier, with bit-selected gains of 1, 2, 4, and 8. It also has a dc-dc converter, an on-board pacer clock with 16 programmable time bases, and resistor pads on the board for eight optional shunt resistors the user can select for differential current loops





OUR MODEL 43 TELEPRINTER FAMILY IS THE BEGINNING OF A NEW LEGEND.

When we introduced it just a year ago, the basic idea behind the Teletype* model 43 proved so sound and flexible that today it's grown into a comprehensive terminal family with extensive capabilities for message communications.

Model 43's come in a variety of configurations with either 80 column friction-feed or 132 column pin-feed printers. Some units are designed for use on the switched network, others for point-to-point private-line systems. (There's also a new generation of 5-level buffered teleprinters for Telex applications.)

The basic model 43 series operates on-line at 10 or 30 cps in either the half- or full-duplex mode and prints multiple copies using the 96 character ASCII code set. A wide choice of interfaces, including EIA RS232C and DC 20-60ma, are available for easy system integration.

With the automatic send-receive configuration, messages can be prepared off-line via the paper tape punch, edited, combined with a master tape, then sent at maximum terminal speed—automatically and unattended—when line rates are lowest.

Buffered 43's operate on-line at speeds ranging from 10 to 180 cps and provide up to 20,000 characters of storage for sending, receiving and editing. These terminals send and receive automatically via the buffer while messages are simultaneously being prepared for future transmission. They also include full forms control, the automatic answer capability and answer back.

Just like its predecessor, the legendary model 33, our model 43 family is designed for extreme reliability. The reason is simple: simplicity. Our model 43's use only five major pluggable components (six, counting the paper tape module on the ASR), along with extensive use of LSI circuitry.

So when you think of our model 43 family, think of it as the beginning of a new legend.

THE TELETYPE MODEL 43 FAMILY.

Teletype Corporation, 5555 Touhy Avenue, Dept. 3185, Skokie, IL 60076. Tel. (312) 982-2000.
*Teletype is a trademark and service mark of the Teletype Corporation.

Circle 191 on reader service card

INTERNATIONAL

OE CRYSTAL OSCILLATOR ELEMENTS

International's OE series of Crystal Oscillator Elements provide a complete crystal controlled signal source. The OE units cover the range 2000 KHz to 160 MHz. The standard OE unit is designed to mount direct on a printed circuit board. Also available is printed circuit board plug-in type.

The various OE units are divided into groups by frequency and by temperature stability. Models OE-20 and OE-30 are temperature compensated units. The listed "Overall Accuracy" includes room temperature or 25° C tolerance and may be considered a maximum value rather than nominal.

All OE units are designed for 9.5 to 15 volts dc operation. The OE-20 and OE-30 require a regulated source to maintain the listed tolerance with input supply less than 12 vdc.

Prices listed include oscillator and crystal. For the plug-in type add the suffix "P" after the OE number; eg OE-1P.

OE-1, 5 and 10 can be supplied to operate at 5 vdc with reduced rf output. Specify 5 vdc when ordering.

Output — 10 dbm min. All oscillators over 66 MHz do not have frequency adjust trimmers.

Catalog	Oscillator Element Type	2000 KHz to 66 MHz	67 MHz to 139 MHz	140 MHz to 160 MHz	Overall Accuracy	25°C Tolerance
035213 035214 035215	OE-1 OE-1 OE-1	$13.50	$15.50	$19.50	±.01% −30° to +60°C	±.005%
035216 035217 035218	OE-5 OE-5 OE-5	$16.75	$19.75	$26.00	±.002% −10° to +60°C	±.0005% 2 −66MHz ±.001% 67 to 139 MHz ±.0025% 140 to 160 MHz

Catalog Number	Oscillator Element Type	4000 KHz to 20000 KHz	Overall Accuracy	25°C Tolerance
035219	OE-10	$19.75	±.0005% −10° to +60°C	Zero trimmer
035220	OE-20	$29.00	±.0005% −30° to +60°C	Zero trimmer
035221	OE-30	$60.00	±.0002% −30° to +60°C	Zero trimmer

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INTERNATIONAL CRYSTAL MFG. CO., INC.
10 North Lee, Oklahoma City, Oklahoma 73102
405/236-3741

New products

of 1–5, 4–20, and 10–50 mA.

In single quantities, the subsystem is priced at $595, which is $100 to $200 cheaper than competing units introduced earlier, Copeland says. The total a-d throughput period is 20 μs, and standard input ranges are ±10 v, ±5 v, ±2.5 v, and ±1.25 v, using the programmable-gain amplifier. Unipolar ranges may be jumper-selected by the user.

The ST-LSI2 can operate in either a program mode or in a direct-memory-access–interrupt mode. (For the latter, an optional DMA-interrupt board, priced at $495, is required.) A diagnostic paper tape supplied with the a-d board exercises all operating modes and provides teletypewriter octal printouts of a-d channels as soon as input wiring is connected and the program is loaded. The ST-LSI2 is memory-mapped, appearing as four consecutive, alterable read/write memory locations.

The on-board pacer clock accepts a 4-bit code in a command word to select one of 16 time bases from 30.6 μs to 1 s. The pacer will start a-d scans, DMA block transfers, or an interrupt. Deliveries of the ST-LSI2 and the DMA-interrupt board are six to eight weeks after receipt of order.

Datel Systems Inc., 1020 Turnpike St., Canton, Mass. 02021. Phone Lawrence Copeland at (617) 828-8000 [381]

High-resolution a-d converter leaves wide-open spaces

Unlike other high-resolution analog-to-digital converters, which seem to take up more real estate than a Texas cattle ranch, the 16-bit MN5820 comes in a 32-pin dual in-line package that measures only 1.72 by 1.12 in. This is less than 25% of the area taken up by other units.

Key to this reduction, according to manufacturer Micro Networks, is use of a combination of up-to-the-minute monolithic chips and thin-film construction techniques. Also ascribed to this combination is the linearity of the successive-approximation hybrid: the converter is

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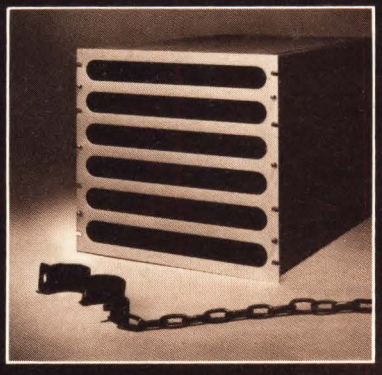

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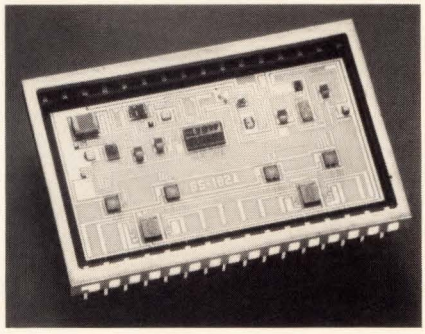
linear to within ±0.003% of its full scale range at 25°C, and to within ±0.006% FSR from 0° to 70°C.

Taking into account errors in offset, gain, and linearity, the converter is absolutely accurate to within ±0.2% FSR at minimum and ±0.1% typically at 25°C in one of its unipolar modes. Across the device's full operating range, those values are



±0.3% and ±0.2% FSR, respectively. Warm-up time for the converter is 3 min.

With a maximum conversion time of 100 μs, the versatile hybrid accommodates six different input ranges: 0 v to 5, 10, or 20 v and ±2.5 v, ±5 v, and ±10 v. Digital outputs are complementary binary in the unipolar mode and complementary offset binary or complementary twos complement in the converter's bipolar mode.

The MN5820 requires ±15-v and +5-v supplies from which it consumes a maximum of 1.8 w, less than other similar units. Not the least impressive aspect of the device is its relatively low price: $219 in singles or $178 in 100s.

Micro Networks Corp., 324 Clark St., Worcester, Mass. 01606. Phone John Munn at (617) 852-5400 [383]

C-MOS a-d converters mate using three-state output

Configured for direct interfacing with a microprocessor's data input/output lines, each member of the ADC-ET analog-to-digital-converter series comes with an enable pin so that the converter's output lines can be driven to a high imped-

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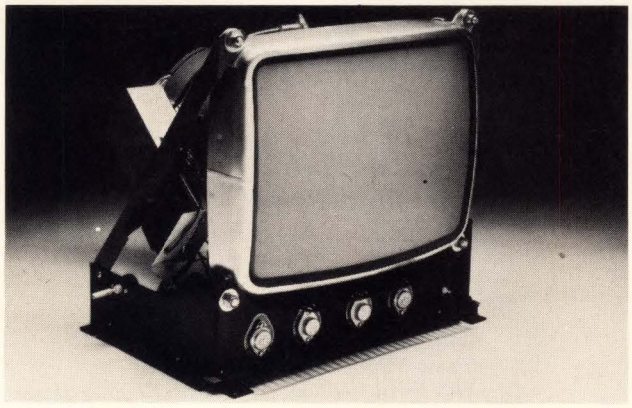
Circle 196 on reader service card



No Frills Color. Just the basics. If you're a black and white terminal manufacturer, the Intecolor 813 is all you need to upgrade your terminals to color.

It consists of an 8-color, 13" CRT, plus a special Analog Module System with all the circuitry necessary to perform deflection and video drive functions for the CRT. The completely self-contained circuitry is on a single printed wiring board which also generates the low voltage, high voltage and CRT bias, mounted on a sturdy aluminum frame for heat sinking the power transistors needed for the circuitry.

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Available in standard 262 Raster line or 400 Raster line high scan versions. If you're ready to upgrade to a color line, call 800/241-9699 toll-free for a demonstration. (In Georgia, call 404/449-5961.)

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ance, thus giving it a three-state output. The complementary-metal-oxide-semiconductor series consists of 8-, 10-, and 12-bit devices, which typically hold nonlinearity to within ±¼ least-significant bit.

Each converter consists of an integrating operational amplifier, a comparator, counters, output latches with three-state drivers, control logic, and an internal clock. An input between 0 and 10 μA is summed with negative pulses of the −20 μA reference current, integrated, and the number of pulses required to maintain the summing input near zero is counted. The binary-coded result is latched into the parallel outputs at the end of the conversion cycle.

Maximum conversion time for the 8-, 10-, and 12-bit models are 1.8, 6.0, and 24 ms, respectively. The units require ±5-v supplies and can operate in a standby mode, with output data latched, while drawing only 200 μA. Depending on the number of output bits and the operating temperature range required, prices vary from $13.50 to $68 in single quantities. Delivery is from stock to four weeks.

Datel Systems Inc., 1020 Turnpike St., Canton, Mass. 02021. Phone (617) 828-8000 [385]

18-bit s-d converter combines two-speed system outputs

Intended for use in two-speed systems, the model 1512 synchro-to-digital converter combines inputs from two synchros or resolvers into a single 18-bit output. Housed in a 3.125-by-2.625-by-0.82-in. package, the module can replace the three similar-sized units needed to perform the function.

Available for a variety of gear ratios, the converter is accurate to within 0.003° and maintains this accuracy despite backlash of as much as 2°. The unit's output can be pin-programmed for formats of 0° to 360° or ±180°. For a typical 400-Hz unit, the tracking rate is 1,440°/s.

The 1512 works from 15-v and

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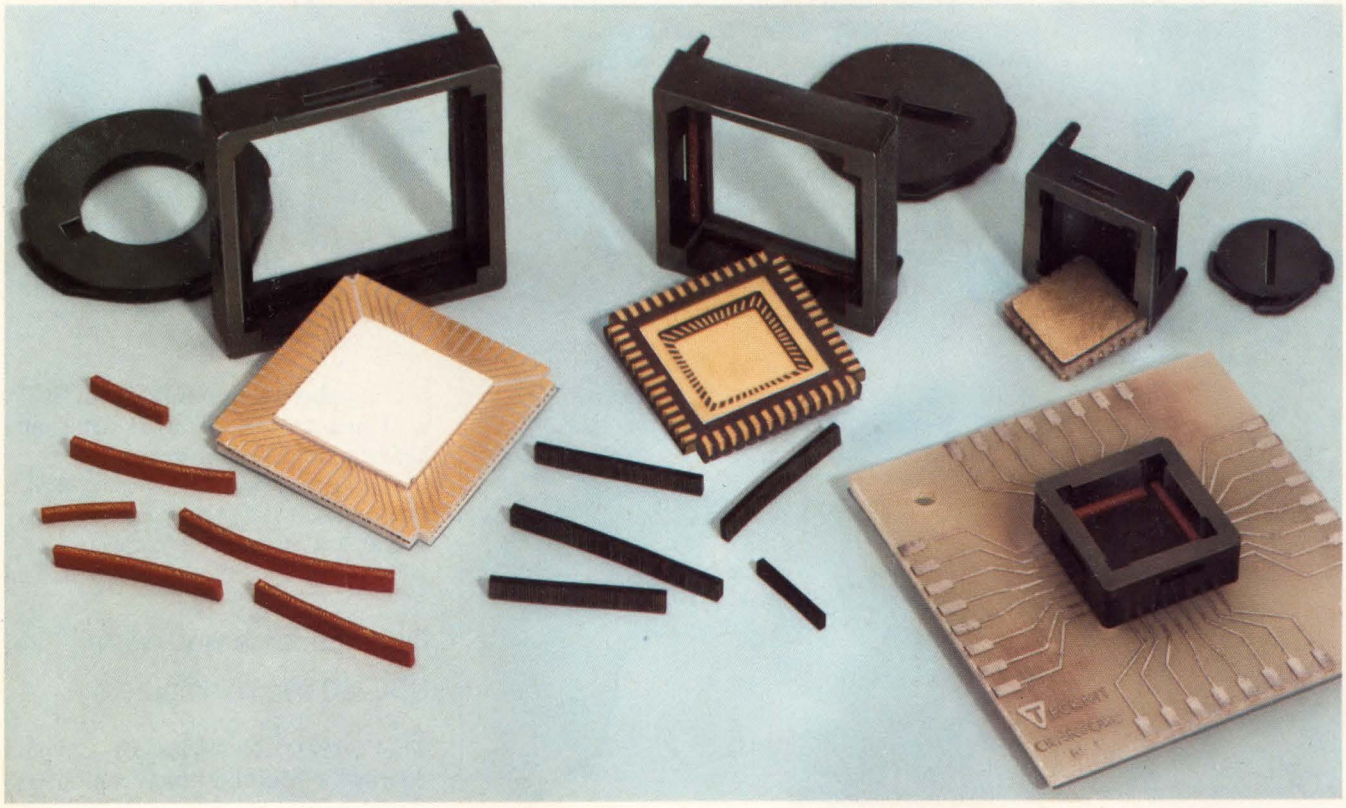

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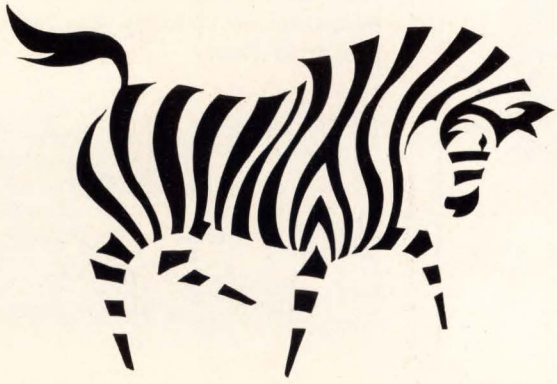

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For literature on the Showcase, Stylist, Compucab or TR Series, write Bud Industries, Inc., 4605 E. 355th St., Willoughby, O. 44094. Bud West, Inc., 3838 N. 36th Ave., Phoenix, AZ. 85019. Or phone toll-free: (800) 321-1764; in Ohio, (800) 362-2265.

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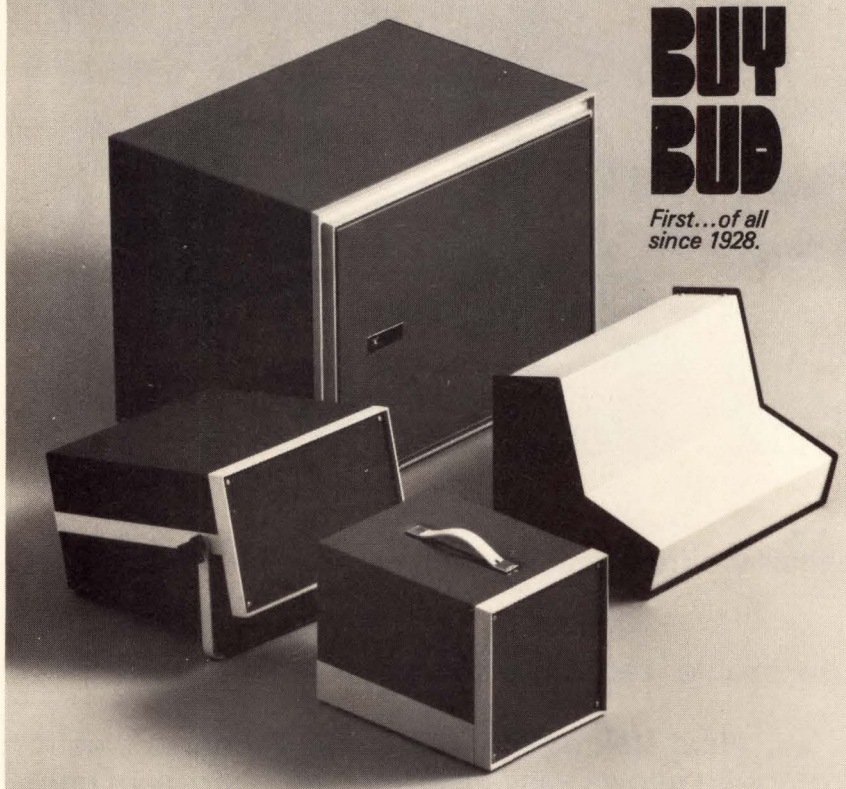

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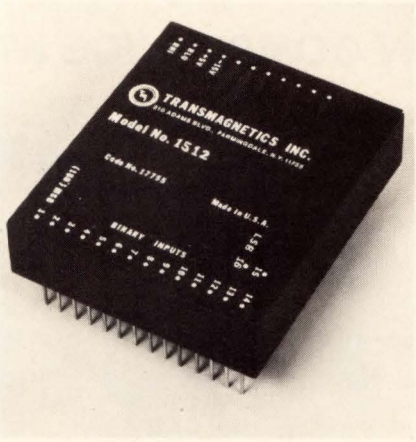


5-v supplies, consuming about 2.75 w. Units are priced at $1,050, and delivery time is eight weeks.

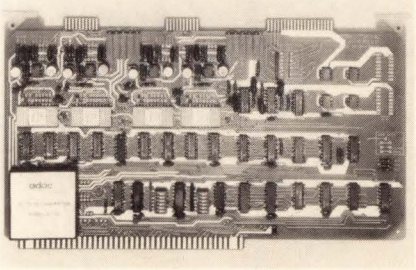
Transmagnetics Inc., 210 Adams Blvd., Farmingdale, N. Y. 11735. Phone Fred Haber at (516) 293-3100 [386]

Output boards work with SBC-80 microcomputers

The 735/DAC series of output boards for Multibus microcomputers (Intel iSBC-80/10, iSBC-80/20, and MDS-800, and National BLC 80/10) includes units with up to four 12-bit digital-to-analog converters. The high-speed converters have double-buffered latches and a programmed pulse circuit for scope blanking and recorder-pen control.

An uncommitted 8-bit read register and a separate 8-bit write register are provided for handling discrete signals. Each of the eight output lines is connected to a driver capable of sinking 300 mA at 32 v—sufficient for driving incandescent lamps and small relays. The four-channel unit sells for $595.

Adac Corp., 15 Cummings Park, Woburn, Mass. 01801 [384]



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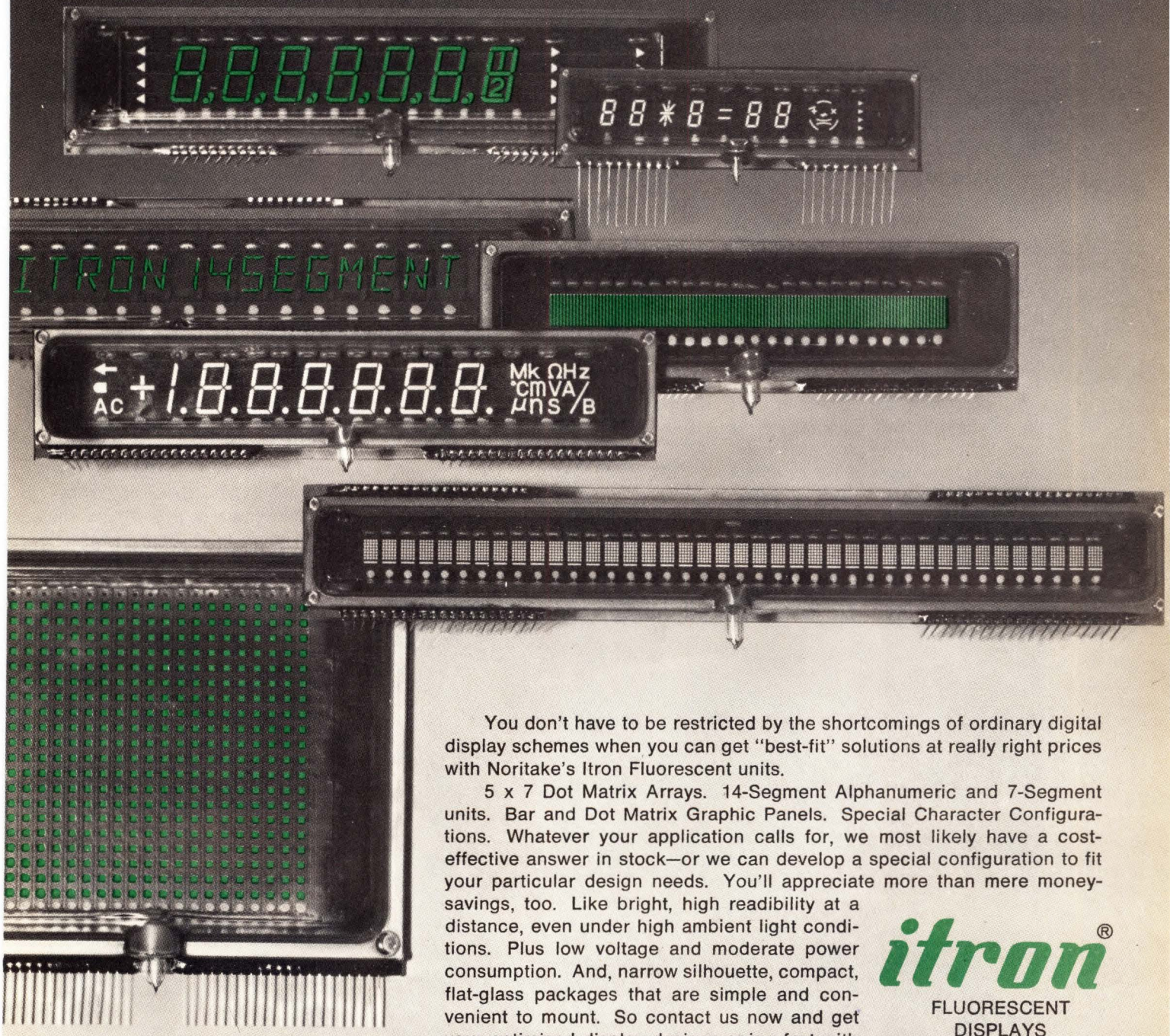

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Circle 263 for Literature Only

Circle 199 for Demonstration

Computers & peripherals

Terminal seconds popular DEC unit

Video console has 15-in. non-glare screen and detachable keyboard

Users of Digital Equipment Corp.'s VT52 video terminal now have a second source. The model VT52-Compat from Ann Arbor Terminals emulates the code structure and functions of that video unit and, in addition, features a large 15-in. non-glare screen, compact size, and a detachable keyboard.

All operating controls are set from the keyboard, thus eliminating the need for control switches. and holding any key depressed for longer than half a second causes its corresponding character code to automatically repeat at approximately 15 characters per second.

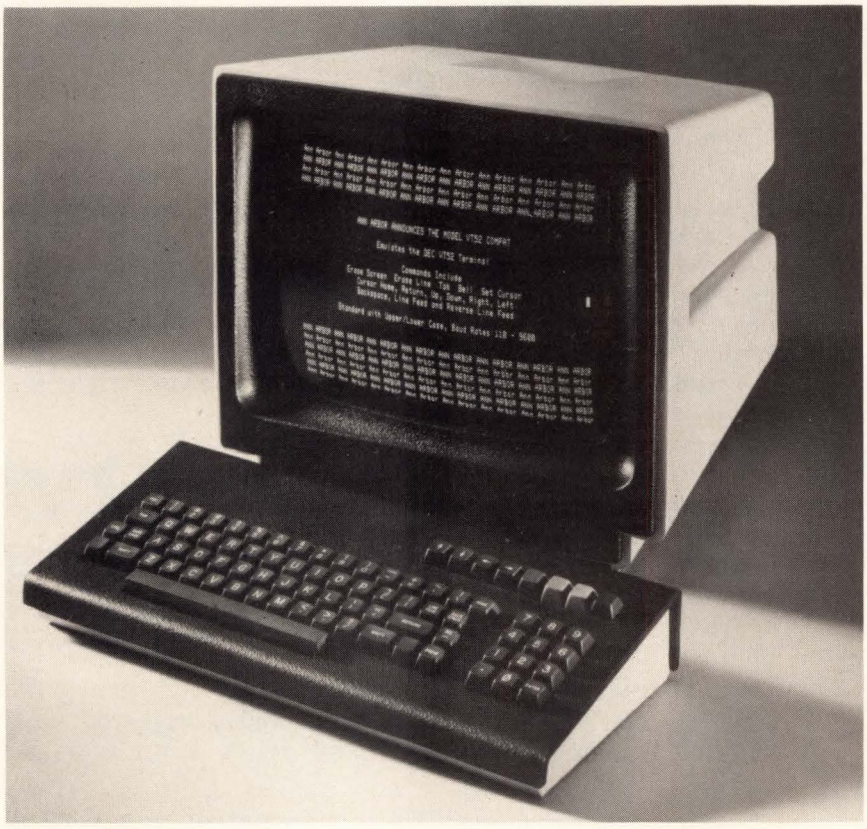
The VT52-Compat's 81-key keyboard generates the full 128-character ASCII set. A separate numeric pad and four cursor control keys are also standard. The shift, control, and caps-lock keys function exactly like those on the VT52. Up to 28 additional special-function keys are available.

All command and control functions may be executed from the keyboard. Commands include: erase screen, erase to end of line, cursor home, return, up, down, right, left, line feed, reverse line feed, backspace, tab, set cursor position, and bell. Control functions are selection of baud rate (110 to 9,600 b/s) and input/output mode (full- or half-duplex). The VT52-Compat displays 24 lines of 80 characters, upper or lower case. The characters are formed with a 7-by-7 dot matrix in a 10-by-10-dot field, and the cursor is seen as a blinking field.

The VT52-Compat measures only 15 in. wide by 14 in. high by 13.6 in. long, plus keyboard, and weighs only 35 lb. The terminal uses Ann Arbor's "smart monitor"—the low number of components permits the terminal and monitor electronics, plus power supply, to be mounted directly on the monitor chassis.

Available options include export power adjustment, current-loop interface, rack mounting panel, as well as a variety of case options. Single quantity prices begin at $1,400. Standard delivery time is eight weeks after receipt of order.

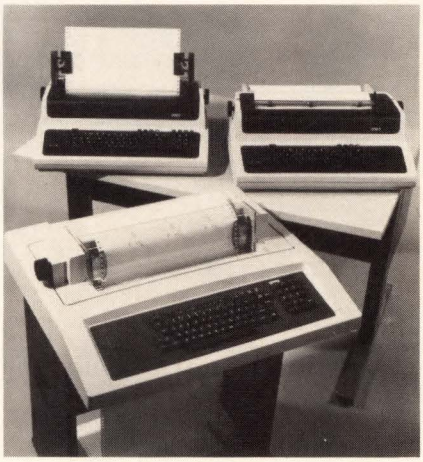
Ann Arbor Terminals, Inc. 6107 Jackson Rd., Ann Arbor, Mich. 48103. Phone Sarah Freeman, marketing coordinator, at (313) 769-0926 [361]



180-character/s printer transmits to 9,600 bauds

In rounding out its line of printers, Digital Equipment Corp. is crowning the series with the DECwriter III, model LA120, which can write across 14⅞-in.-wide paper at a rate of 180 characters per second [*Electronics*, November 9, p. 189]. Yet the new device is more than fast: it is also flexible. Using the DECwriter III's keyboard or under program control, users can select from 45 different features.

Among those features are data transmission rates from 50 to 9,600 bits/s for serial, asynchronous transfers. Capable of printing a full set of upper and lower case ASCII characters, the printer offers a choice of eight font sizes, ranging from 5 to 16.5 characters/in., and vertical line spacings of 2 to 12 lines/in. The bidirectional track-feed printer



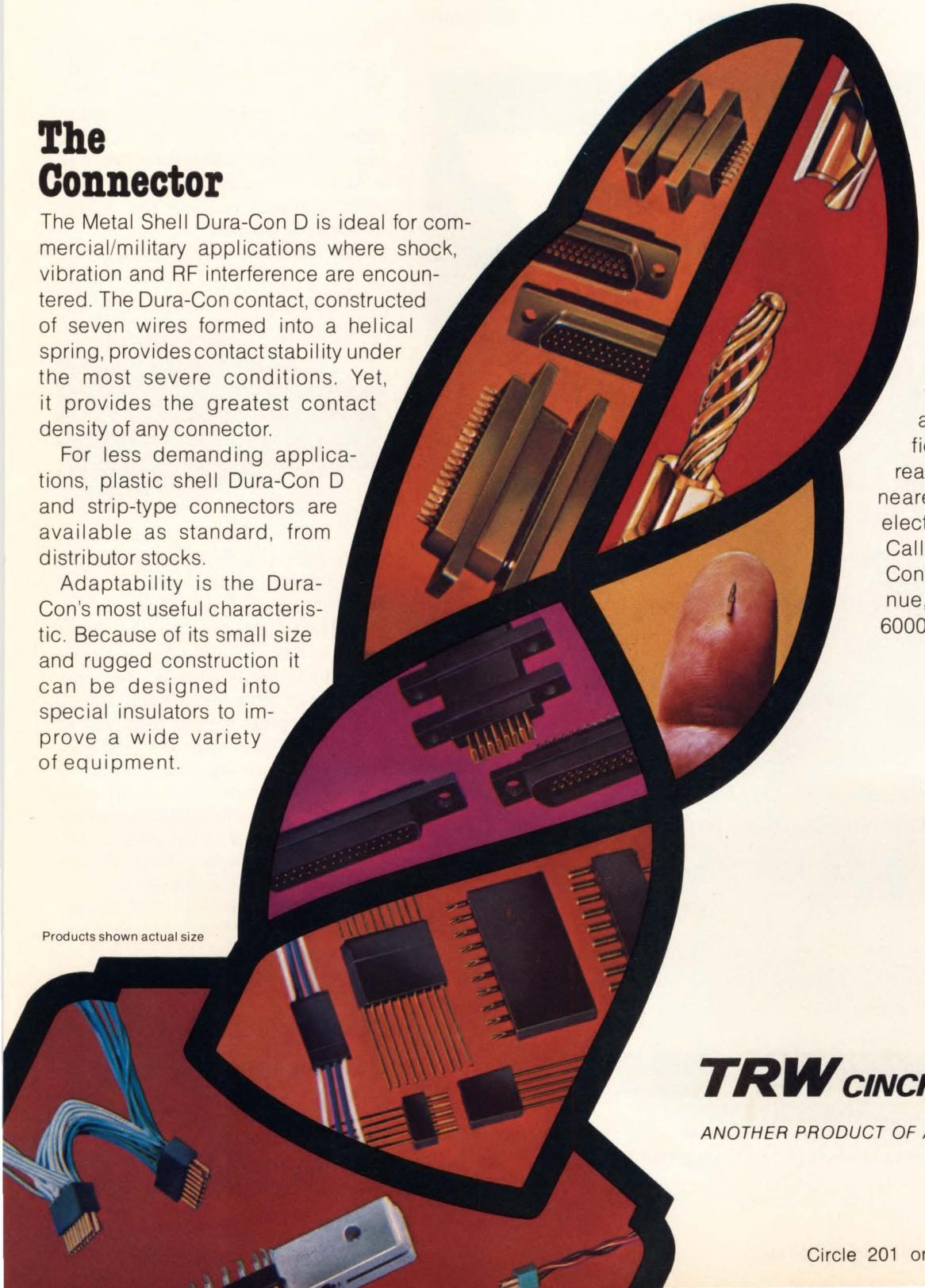
Newest microminiature high reliability Dura-Con™ connector is RF shielded, too.

The Connector

The Metal Shell Dura-Con D is ideal for commercial/military applications where shock, vibration and RF interference are encountered. The Dura-Con contact, constructed of seven wires formed into a helical spring, provides contact stability under the most severe conditions. Yet, it provides the greatest contact density of any connector.

For less demanding applications, plastic shell Dura-Con D and strip-type connectors are available as standard, from distributor stocks.

Adaptability is the Dura-Con's most useful characteristic. Because of its small size and rugged construction it can be designed into special insulators to improve a wide variety of equipment.



Products shown actual size

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Circle 201 on reader service card

quickly skips over nonprinting areas and responds to horizontal and vertical commands. Its print head can be positioned relatively as well as absolutely; it can, for example, print superscripts and subscripts.

For those applications that require more than the usual interaction between user and computer, a larger buffer is offered. The standard 1,024-character buffer can be expanded to 4,096 characters, and both buffers use true nonvolatile storage—no batteries are needed.

The DECwriter III stands 33.5 in. tall and measures 27.5 in. wide by 24 in. deep. Deliveries will begin next month. In lots of 100, the printers are priced at $1,830 each.

Digital Equipment Corp., Maynard, Mass. 01754. Phone Paul Preo at (617) 481-7400 [363]

Memory for PDP-11/70 adds up to 1.5 megabytes

The PM-SJ11 is a high-speed memory consisting of from three to eight hex-wide boards for use with PDP-11/70 minicomputers. Using metal-oxide-semiconductor parts, the memory system increases storage to a maximum capacity of 1.5 megabytes, about three times the storage of competitive units.

The system consists of from one to

six memory cards, each containing 256 kilobytes of storage space, and two controller cards. These boards provide the interface to the PDP-11/70's bus, in addition to error-correcting, parity-control, memory-timing, and error-logging circuitry.

The complete system is housed in a 5.25-by-19-in. chassis that provides power, cooling, and front-panel operator controls, and it mounts directly in the minicomputer's memory bay. A version of the system with a 128-kilobyte memory board is also available for smaller systems.

Plessey Peripheral Systems, 17466 Daimler, Irvine, Calif. 92714. Phone Gerard Mottier at (714) 540-9945 [365]

Storage-interface unit gives terminal brains

Rather than trade in their data entry stations for newer, more sophisticated terminals, owners of dumb terminals can simply add intelli-

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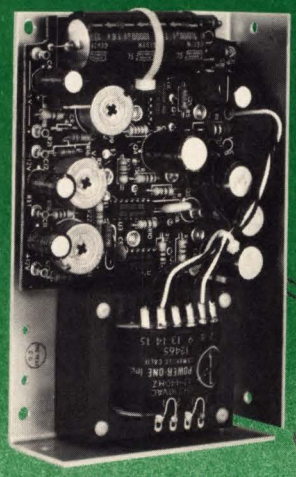

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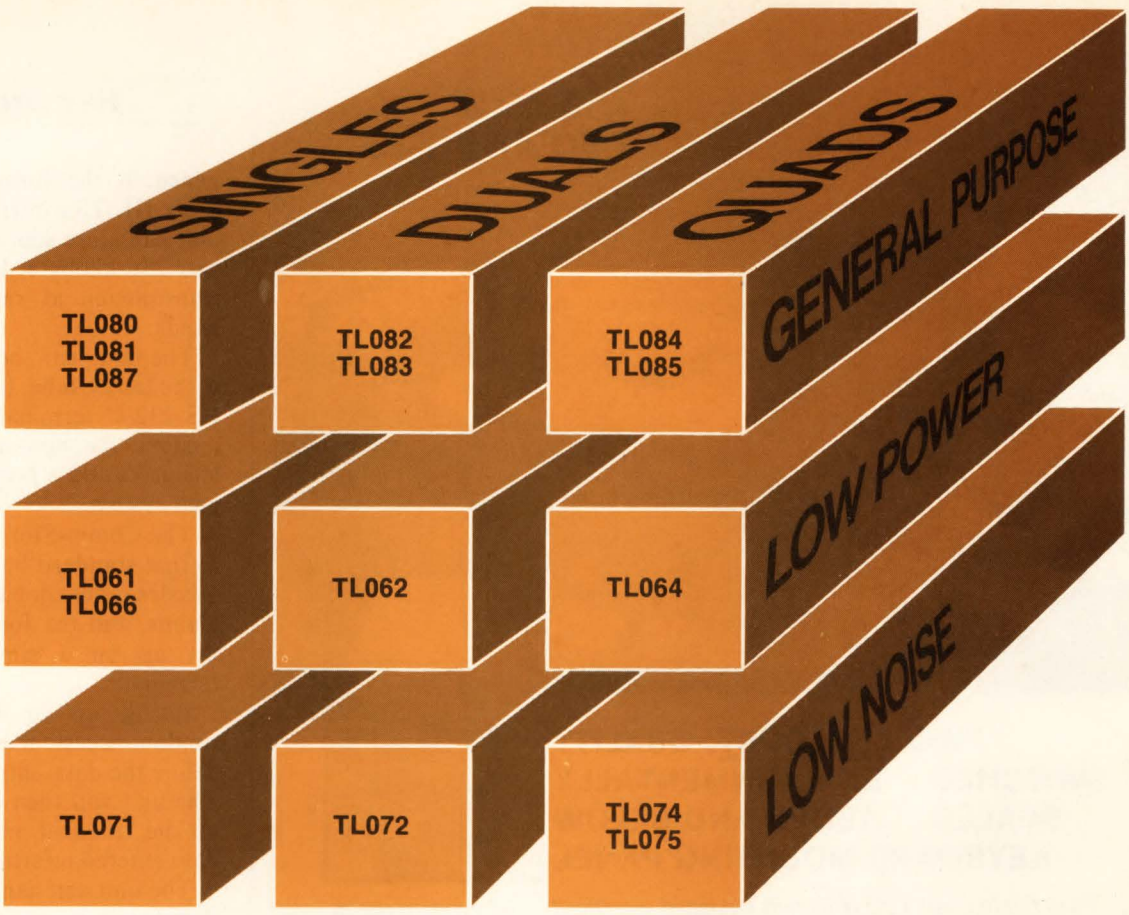

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For more information, see your authorized TI distributor or write Texas Instruments Incorporated, P.O. Box 225012, M/S 308, Dallas, Texas 75265.

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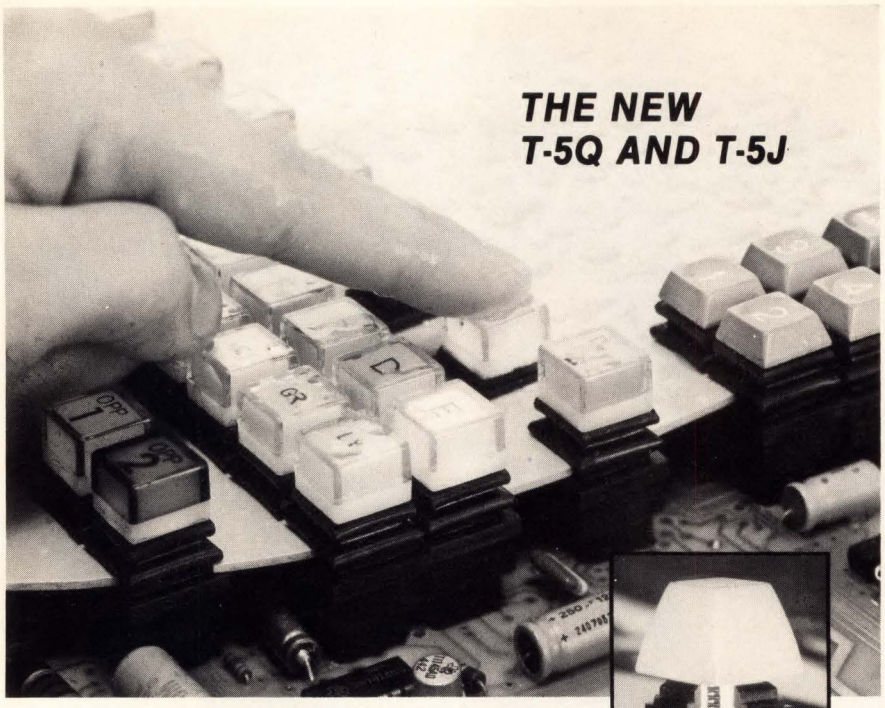
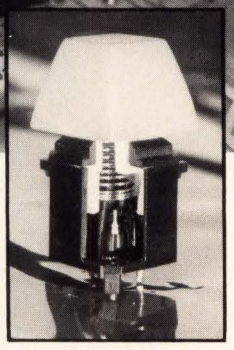
Circle 214 on reader service card



THE NEW T-5Q AND T-5J



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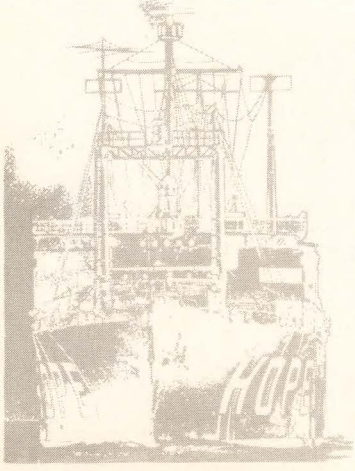
Circle 215 on reader service card



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New products

gence in the form of the Comm-Storr III. This microcomputer-based unit can store source data on one or two 256-kilobyte diskettes for later transmission at rates up to 9,600 bauds.

The unit can be connected to a cathode-ray-tube, hardcopy, or other RS-232-C terminal as well as to a modem. An optional interface also lets users add a printer to the intelligent system.

The Comm-Storr III was designed so that standard business forms such as sales orders, job reports, insurance claims, and tax forms can easily be set up on a simple, inexpensive terminal.

Using up to 12 kilobytes of random-access memory, users can define the data-entry format desired. The unit will then display that form on the terminal and store and validate entered information.

The unit can handle multiple-page forms and variable-length files and will automatically fill in data fields. It also translates diskette data in ASCII format to EBCDIC format and writes appropriate labels for direct reading by IBM-3740–compatible equipment.

The basic Comm-Storr III, with 4 kilobytes of RAM and a single disk drive, costs $3,375.

Sykes Datatronics Inc., 375 Orchard St., Rochester, N. Y. 14606. Phone Al Montevecchio at (716) 458-8000 [364]

Drum plotter quietly draws 42-in.-wide graphs quickly

With the Complot DP-9 drum plotter, drawings up to 42-in. wide can be created using three programmable pens. The plotter moves paper at speeds up to 1.63 in./s.

Six step sizes, ranging from 0.00125 to 0.01 in., are selectable using a switch calibrated both in inches and millimeters. A joy stick can be used to control pen and chart. The DP-9 is priced at $13,500, and its delivery time is 60 days.

Houston Instrument, 1 Hudson Square, Austin, Texas 78753. Phone Rod Schaffner at (512) 837-2820 [366]

How to meet European suppression regulations without getting a lot of interference.

European countries have stringent interference suppression regulations for power line connected equipment. What's more, similar regulations are under consideration right now in the U.S.

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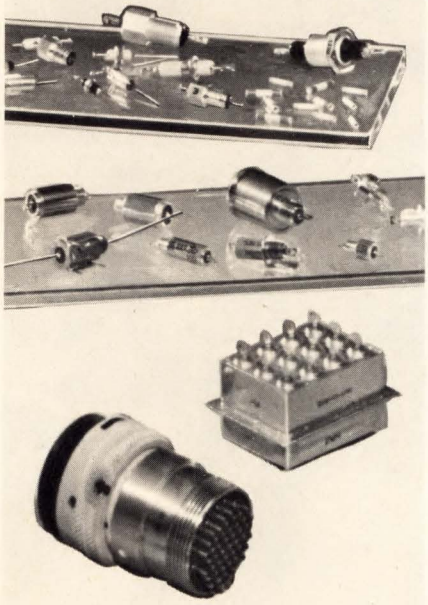

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Instruments

Tiny DPM needs only 70 mW

3½-digit meter with liquid-crystal display occupies 1.75 in.³, sells for $69

Three things about Velonex' series 37K digital panel meters are small: the dimensions, the price, and the power consumption. But the performance (3½-digit resolution with maximum error of 0.05% of reading plus one count) most certainly is not. This latest effort in the Varian division's five-year-old DPM activity, like its V2300 series of meters that qualify under MIL-STD-202, departs from what most other DPM makers are doing.

Instead of starting with a $30 or $40 "cheapie" meter and then scaling up in price and features, Velonex has done just the opposite. In scaling down from its series 35 3½-digit meters to this new set, the company has integrated and modularized while shrinking size and lowering power dissipation along the way. The upshot is that the price, too, has fallen—from $99 for the 35 to $69 for the 37K in 100 quantity. "At $100, anyone needing 250 to 300 meters could reasonably elect to build instead of buy," George Obinger, marketing manager says. But at $69, he feels, the "make" decision gets pushed way back in the numbers.

Achieving the small size (2.8 in. wide, 1.25 in. high, and 0.5 in. deep) and low power dissipation was an evolutionary process. Borrowing from the techniques used in its earlier models, Velonex worked to reduce parts count and size using custom complementary-metal-oxide-semiconductor integrated circuits and modular displays with built-in drivers. To gain even more space, it used unpackaged chips bonded directly to the circuit board and covered with epoxy.

Nevertheless, until this series, the DPMs had the usual display and associated bezel, with a rectangular box housing the electronics protruding behind. Now, everything—the electronics and 0.5 inch liquid-crystal display—is mounted on one board housed in what had previously been only the display bezel. There was even room for the dc-to-dc converter circuitry required to develop the IC supply voltage from the single 5-V input supply.

Low-power operation results from using not light-emitting diodes but liquid crystals, for the meter's display. In fact, most of the 70 mW consumed by the model 37K is eaten up by the dc-to-dc circuitry. When that circuitry is absent, in the battery-operated J version, power consumption drops to around 10 mW, making it ideal for battery-powered portable instruments.

The 37K's other specifications are equally impressive: 100 dB of common-mode rejection measured with 1-kΩ imbalance, 100-ppm/°C temperature coefficient measured over the 0°-to-40°-C range (specified operating range is 0° to 50°C) dropping to 50 ppm/°C in the optional T version, and the ability to withstand without damage 200 V dc or peak ac in the first three of four voltage ranges (199.9 mV, 1.999 V, and 19.99 V) and up to 500 V dc or peak ac in the 199.9-V range.

These DPMs will be available for delivery after Dec. 15, according to Obinger, and will come in standard black or special colors (in very large quantities). Another version of the 37K using high-efficiency red LED

displays will be available soon, Obinger says, but specifications for that meter are not yet complete.

Velonex, 560 Robert Ave., Santa Clara, Calif. 95050. Phone (408) 244-7370 [351]

30-MHz pulse-function generator sells for $995

The latest generator from Exact Electronics Inc. is a pulse and function unit with four simultaneous outputs: TTL, $\overline{\text{TTL}}$, ECL, and $\overline{\text{ECL}}$. The generator, which has a frequency range and pulse-repetition-rate range of 0.0001 Hz to 30 MHz, produces sine, square, and triangular waveforms, as well as positive-going and negative-going pulses.

The combination of normal and complemented signals from its emitter-coupled and transistor-transistor-logic outputs allows the model 734 to apply a signal and its complement to two nodes simultaneously. Most other generators have switched inversion but only a single output, so to generate a signal and its complement simultaneously, their output must be buffered and inverted.

Although priced at $995, the 734 has the performance and features of more expensive units. Both frequency and amplitude are guaranteed stable to within 0.05% of setting and maximum peak-to-peak amplitude, respectively, over a 10-minute interval or to within 0.25% over 24 hours. Rise and fall times for square waves and pulses are less than 10 ns. A dc offset may be switched in and out as may double-pulse and delayed-pulse operations.

Frequency and period are continuously variable, whereas amplitude may be attenuated up to 60 dB in six 10-dB steps and then trimmed over a 20-dB range with a potentiometer control. The pulse width can be adjusted from 10 ns to 10 ms and the delay may be varied by the user from 20 ns to 10 ms.

Exact Electronics Inc., 455 S. E. 2nd Ave., Hillsboro, Ore. 97123. Phone (503) 842-8441 [352]

LC bridge measures at selectable frequencies

Since all real capacitors and inductors are frequency-sensitive elements, characterizing them at two or three fixed frequencies is insufficient for some applications, particularly in military systems. The model 1688 digital inductance-capacitance bridge, therefore, lets operators select any of 254 frequencies between 240 Hz and 20 kHz at which to perform measurements.

Called Digibridge, the instrument

has capacitance and inductance ranges of 0.0001 pF to 9999.9 μF and 0.00001 mH to 9999.9 H, respectively. Quality and dissipation factors from 0.0001 to 999.9 can be measured, and D values from 1 to 9,999 ppm can also be read in an extended-accuracy mode. Test-voltage levels of 0.25 or 1 V rms may be selected. Sample accuracies for the bridge are 0.02% of reading for capacitance and ± 1 digit for D.

The instrument has a built-in Kelvin test fixture that accommodates both axial- and radial-lead components; extender cables are offered as an option for connection to custom test fixtures (auto-zeroing eliminates stray capacitance and

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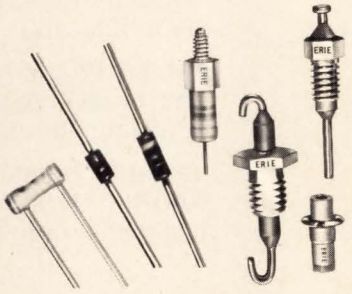

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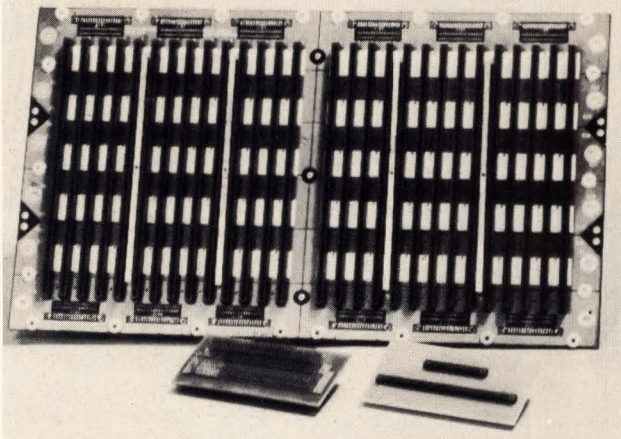

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New products

inductance that introduce errors).

The 1688 can optionally be configured with an IEEE-488 interface and autohandler output, so it can easily be incorporated into automated test systems. The instrument can automatically sort components into symmetrical or asymmetrical tolerance categories and test at any of four selectable speeds up to one every 130 ms. It is priced at $4,200.

GenRad Inc. 300 Baker Ave., Concord, Mass. 01742. Phone (617) 369-4400 [354]

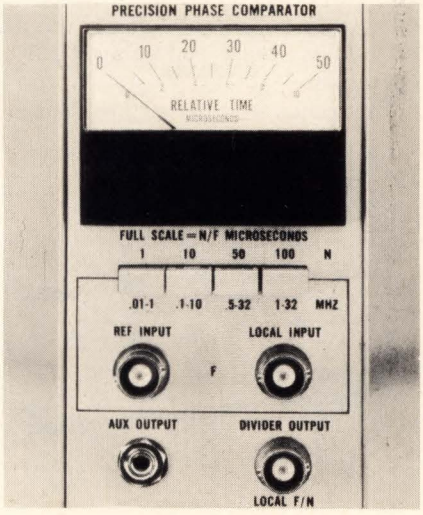
TM-500-compatible plug-in compares phases to 32 MHz

A plug-in unit for the TM-500 power module, the model 8150 is a phase comparator that accepts 10-kHz to 32-MHz input signals with amplitudes of 0.1 to 10 v rms. The comparator's meter expresses phase difference as a relative time between a reference and a local signal.

Five ranges from 0.1 to 100 μs, full scale, are provided; resolution on the lowest range is 10 ns and end-of-scale error on that range is typically less than −5% of full scale.

An auxiliary output on the front panel can be used to drive an external chart recorder for long-term drift measurements and the divider output yields the local frequency divided by an integer, N. The 8150 is priced at $750.

Spectracom Corp., 1667 Penfield Rd., Rochester, N.Y. 14625.



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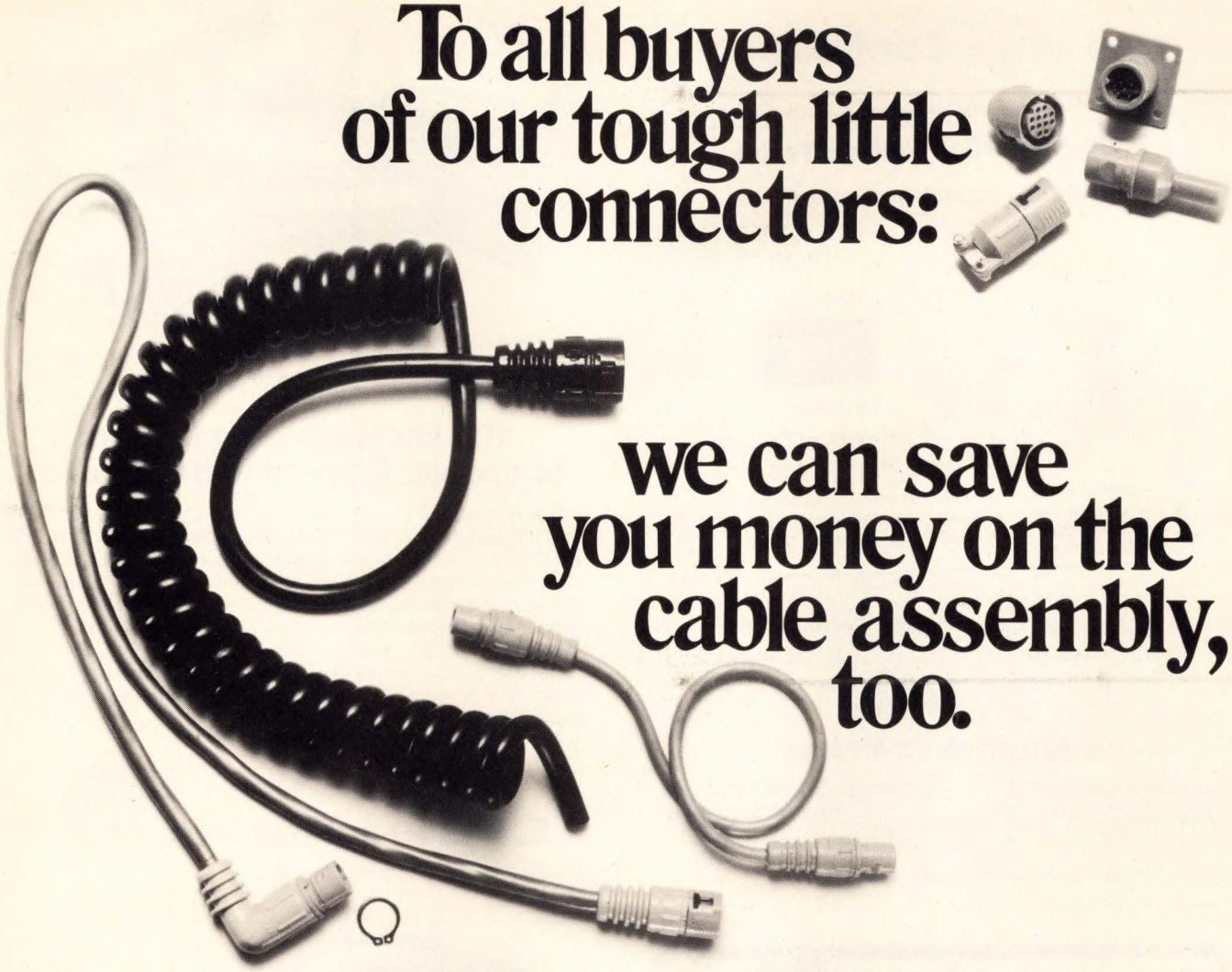

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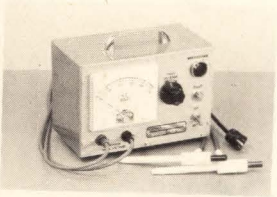

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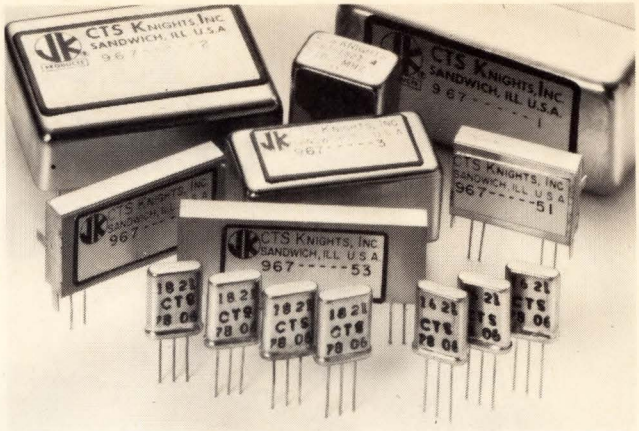

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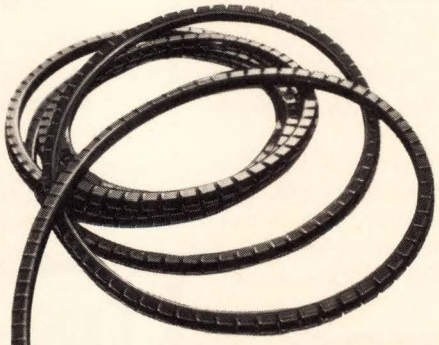

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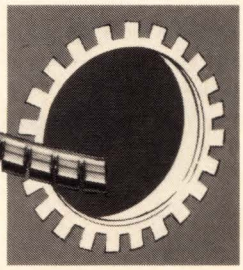

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Products newsletter

Memory testers start to move

The past month has given rise to several memory test systems and options for existing systems. Macrodata Corp. of Woodland Hills, Calif., started things off with its M-1—the industry's first true 25-MHz unit [*Electronics*, Oct. 26, p. 229]. Joining the 25-MHz race is the 5582 by the Xincom Systems division of Fairchild Camera and Instrument Corp., Chatsworth, Calif. **Both of these machines are responses to a need for memory testing at actual operating rates.** In response to a somewhat different need, the addition of real-time bit mapping to the J387 memory test system from Teradyne Inc., Boston, provides the engineer with insights into device failure modes—needed to increase yields and characterize some devices. A color graphics terminal displays bit failures in a spectrum of colors that correspond to individual tests that have been performed. Interactive control using a remote joy stick allows the user to change parameter values and select tests.

Bare board testing for hire

Equipment for 100% electrical inspection and testing of bare printed-circuit boards is often too expensive for small and medium electronic firms. However now the EMS division of Everett/Charles Inc., Santa Ana, Calif., has **a contract service for testing bare boards up to 20 by 24 inches in size.** EMS uses Everett/Charles series 50 circuit verifiers and the parent company's series 32 fixturing systems. Use of the testing service is reported to minimize start up costs for testing of new products and the expense of board repairs discovered during or after assembly.

Semicustom C-MOS cuts chip count

A new family of semicustom complementary-MOS integrated circuits has been introduced by California Devices Inc., Santa Clara, Calif. **These large-scale integrated arrays are designed to replace TTL and C-MOS small- and medium-scale integrated parts at the system level.** A single semicustom circuit typically replaces 10 to 40 standard ICs. The basic family includes seven chips, ranging from the smallest 50-gate array to a 600-gate device containing over 25 transistors and up to 74 input/output pins. Integration is done directly from TTL/C-MOS logic drawings without the need for redesign. Development prices start as low as $2,400, with delivery in four weeks. More typically, costs are $6,000, with delivery in seven weeks for average circuits. Production pricing ranges from 1½¢ to 7¢ per gate, depending on volume, packaging, and chip size.

SKF to market active magnetic bearings in U. S.

Will electronics force another mechanical device to bite the dust? Calling them frictionless, noise-free alternatives to conventional ball, roller, and hydrodynamic bearings, SKF Industries Inc. of King of Prussia, Pa., has brought the European technology of active magnetic bearings to the U. S.

Active magnetic bearings support rotating shafts by suspending them in mid-air in a magnetic field that is precisely controlled by an electronic shaft-position-sensing feedback loop. Bearing capacity is at present limited to about 4,000 lb by the current available from power transistors used to drive the magnetic-field coils. The 550-V, 30-A devices have passed preliminary tests and promise to hike load-carrying capacity to 10–50 tons.

South Dakota
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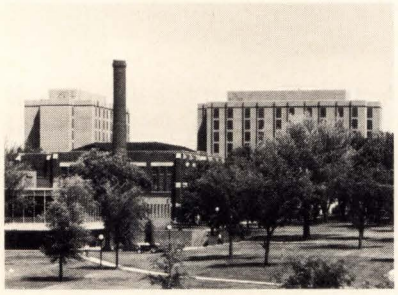

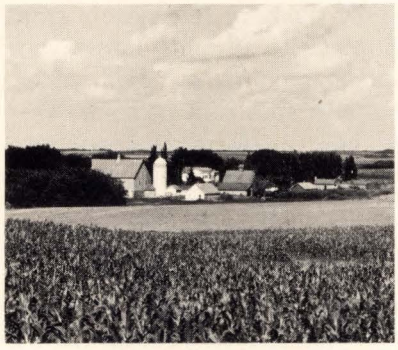

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Multicore Solders, Westbury, N. Y. 11590 [476]

An epoxy rubber made from a low-viscosity resin is good for applications requiring inspection, testing, or repair of embedded components. Cured at room temperature, PR-2037 has been used for bonding lenses and for laminating glass safety shields and cathode-ray tubes. This two-component material, which has a 1:1 mix ratio, can easily be cut away to remove defective components and repotted with fresh material. It has a dielectric strength of 420 volts/mil and a volume resistivity of 1.0×10^{13}. It also has a tensile strength of 875 lb/in.^{2} and exhibits a weight loss of 1.1% for 24 hours at 150°C. The material can be cured for 24 to 36 hours at room temperature, 12 hr at 60°C, and 2 to 4 hr at 90°C. The resin sells for $2.65 in quart cans, $2.40 in 1-gallon cans, and $2.20 in 5-gallon pails. The catalyst goes for $3.10 in quart cans, $2.85 in 1-gallon cans, and $2.65 in 5-gallon pails.
Formulated Resins Inc., P. O. Box 508, Greenville, R. I. 02828 [477]

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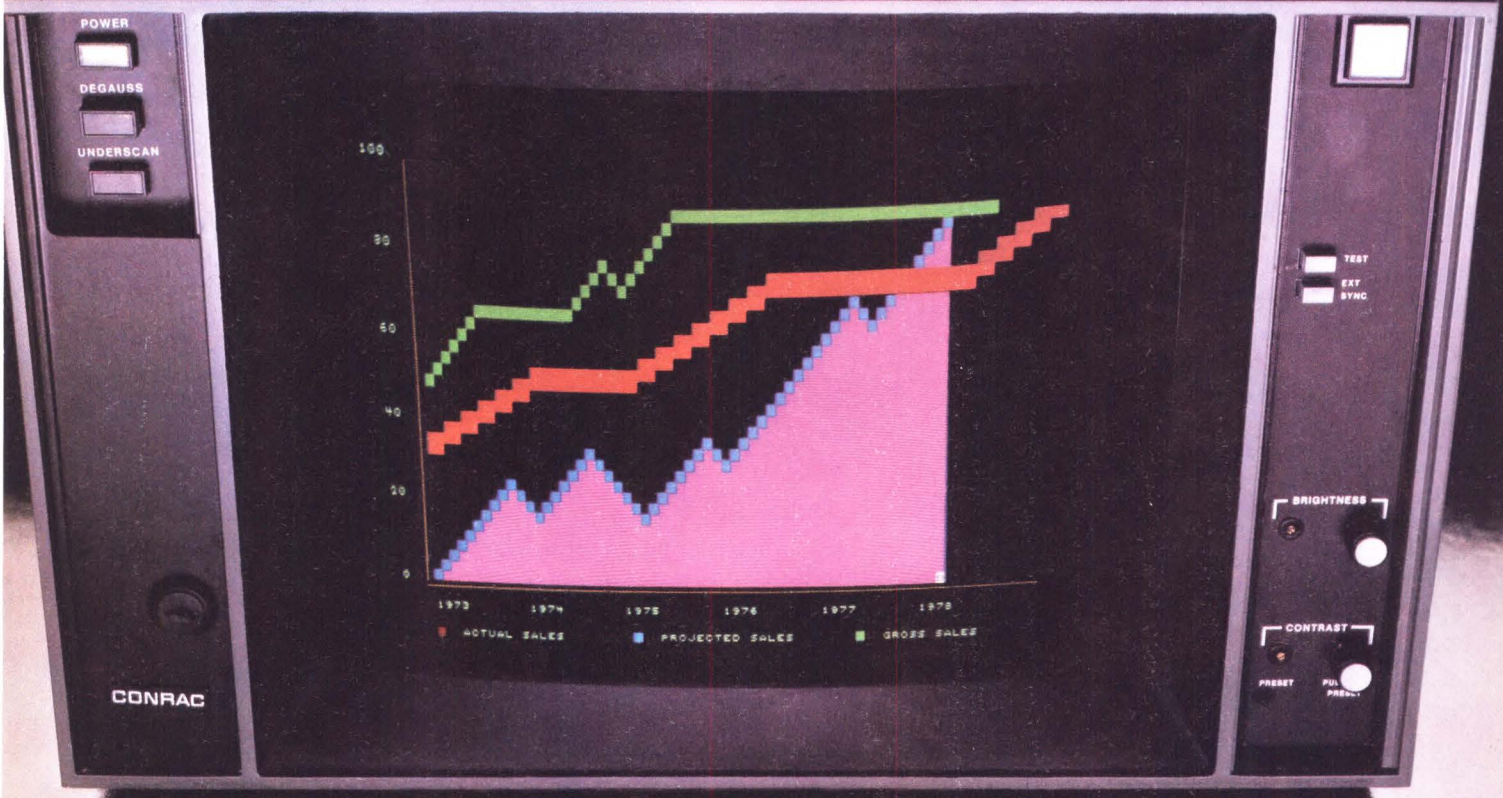

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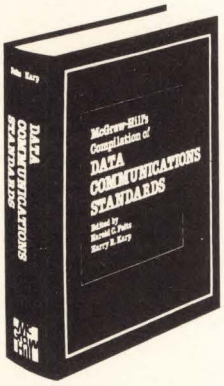

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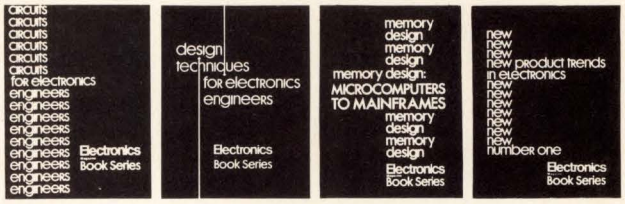

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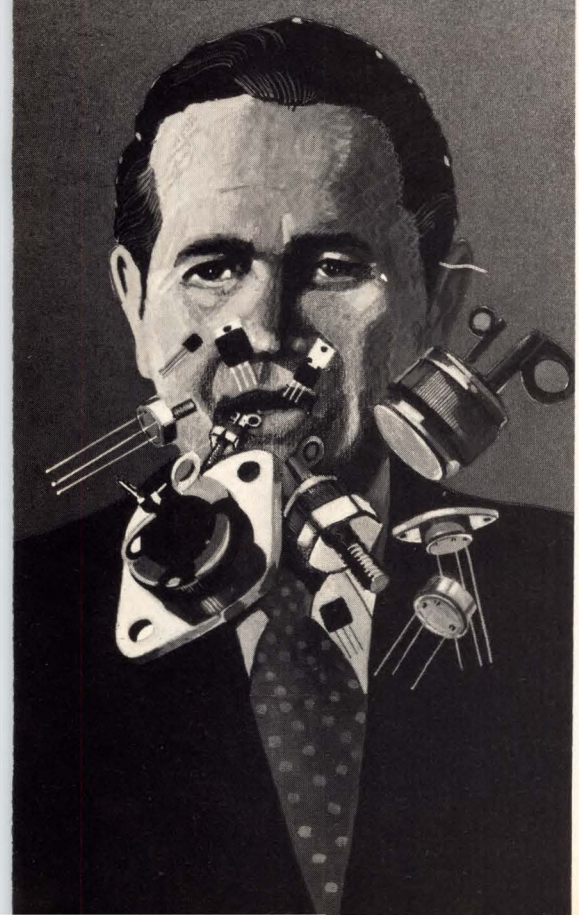


New literature

Resistors. The "Thin-Film Resistor Network Catalog" covers the models 698 16-pin and 699 14-pin thin-film resistor networks. For each type, performance, mechanical, and environmental specifications are provided. Standard resistance values and power-dissipation ratings are given as well. Beckman Instruments Inc., Technical Information Service, Advanced Electro-Products Division, P. O. Box 3100, Fullerton, Calif. 92634. Circle reader service number 421.

Analog and digital circuits. The "Cherry Catalog" presents information on several types of circuits and systems, including differential amplifiers, level detectors, dc-dc converters, timing circuits, motor-speed

controls, optical detector systems, camera-control systems, and flip chips. It may be obtained from Cherry Semiconductor Corp., 99 Bald Hill Rd., Cranston, R. I. 02920 [422]

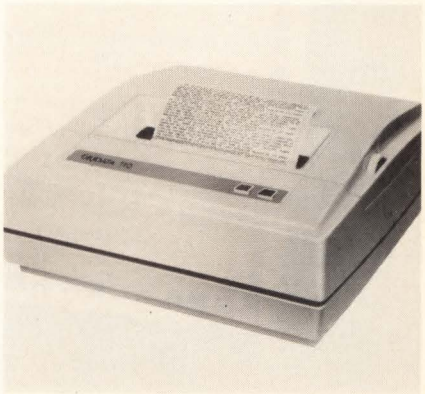
Cables. "Signal Transmission Cable," an eight-page brochure, examines twisted pairs, three types of coaxial cable, twin- and three-lead flat flexible transmission cable, and fiber optics. Tables compare the characteristics for the different types of signal-transmission cables. It can be obtained from Brand-Rex Co., P. O. Box 498, Willimantic, Conn. 06226 [423]

Rf filters. Listed in a 20-page catalog are nearly 200 coaxial filters, filter-couplers, and filter-coupler-switches, with performance data and mechanical specifications of low-pass, high-pass, and bandpass models having cutoff frequencies from 1 megahertz to 2.7 gigahertz. A separate section explains how to avoid overspecifying filters. Bird Electronic Corp., 30303 Aurora Rd., Cleveland, Ohio 44139 [424]

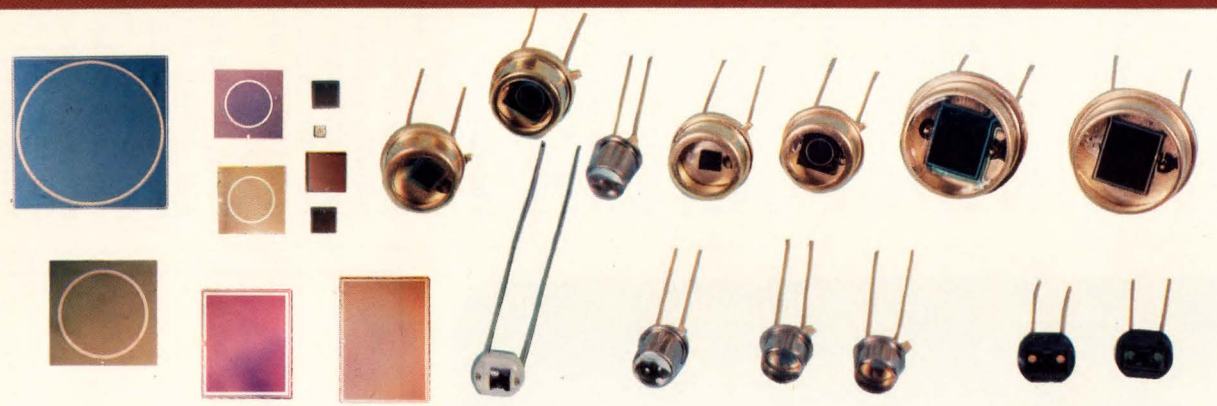
Stepper motors. Intended for designers, "Stepper Motor Handbook" contains sections on the technology, applications, and formulas for these components. The formulas are presented in metric SI terminology. Detailed specifications, torque vs step-rate graphs, wiring diagrams, and dimensional drawings for 11 series of motors are given. A separate section describes drive units that are available for these motors. North American Philips Controls Corp., Cheshire, Conn. 06410 [425]

Test equipment. Described in "Follow the Leader in Test Technology," a six-page brochure, are various types of test systems. Some of those included are the 1140 universal transmission-measuring system and 1145 universal signal source, the 9500B channel-bank set, the 1110A noise-measuring set, and the 1202 B phase jitter test set. Copies can be obtained from Telecommunications Technology Inc., 555 Del Rey Ave., Sunnyvale, Calif. 94086 [426]

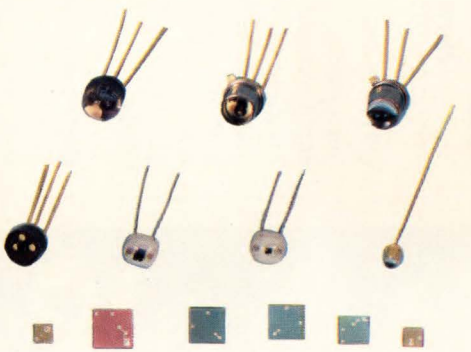
Hardware and software interface. "CP110-8080 Interfacing Aplication Note" details how to interface the



VACTEC Photodetectors



Dumb looking little chips for silicon are tough to advertise. They don't look like much, but they do remarkable things, if you can use microamperes of light current (at 100 f.c.) vs. picoamperes of dark current for a million-to-one signal-to-noise ratio. Linearity and stability are super with a surprising response to visible and blue light (400 nm). These BES (blue enhanced silicon) photodiodes are available in a variety of ceramic or metal hermetic packages so that you needn't be expert at handling these insignificant looking chips.



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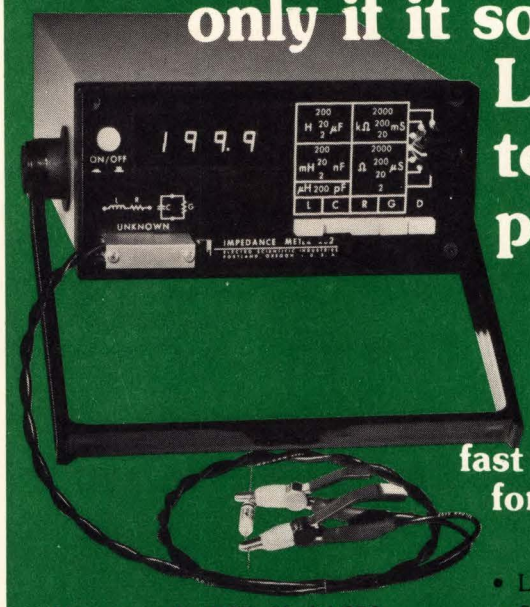

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New literature

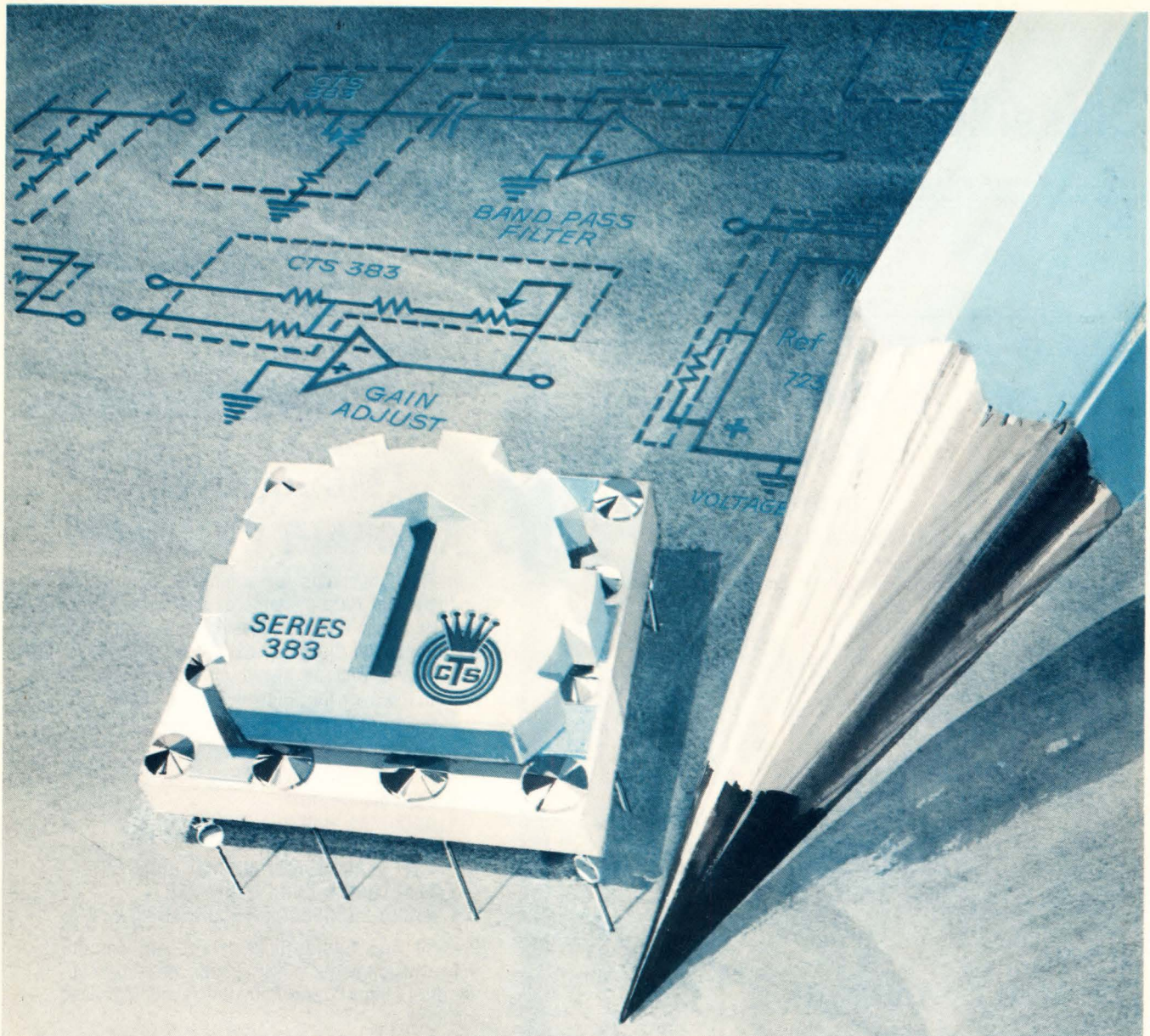
CP110 printer with an Intel 8080 microprocessor. It provides an in-depth explanation of both the hardware and the software needed. Schematics for both are given, along with a sample program listing. The note sells for $2 a copy. Okidata Corp., 111 Gaither Dr., Mt. Laurel, N. J. 08054

Digital rf power-ratio measurements. Techniques for measuring insertion loss, return loss, gain, and coupling factors are discussed in Application Note 17, entitled "RF Power Ratio Measurements Made Easy." The note shows how power-ratio measurements can be simplified by using a power meter with multiplexed power heads. Automation of the same measurements using the IEEE 488 bus and a calculator is also discussed, along with elementary programming and specific setups and procedures for bench measurements. Four sample programs are included. Pacific Measurements Inc., 470 San Antonio Rd., Palo Alto, Calif. 94306 [428]

Frequency sources and modules. Specifications and descriptions for a series of modular frequency synthesizers operating from 0.001 hertz to 160 megahertz, sine-wave converter modules, and attenuator and programmable function generator modules are being offered in an eight-page brochure. Syntest, 169 Millham St., Marlboro, Mass. 01752 [429]

Coaxial connectors. A 36-page reference catalog provides information on the SMB/SMC Conhex, the SRM, SMA, and the microminiature Nanohex connectors. Electrical and mechanical specifications are provided for each type. Sealectro Corp., Mamaroneck, N. Y. 10543 [430]

Relays. "Solid State Relays," a 17-page catalog, provides descriptions for miniature 2.5- and 4-ampere printed-circuit mount and plug-in relays and 6-, 10-, and 15-bulkhead mount relays in standard packages. Grayhill Inc., 561 Hillgrove, La Grange, Ill. 60525 [431]



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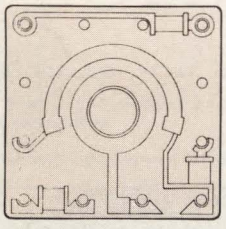

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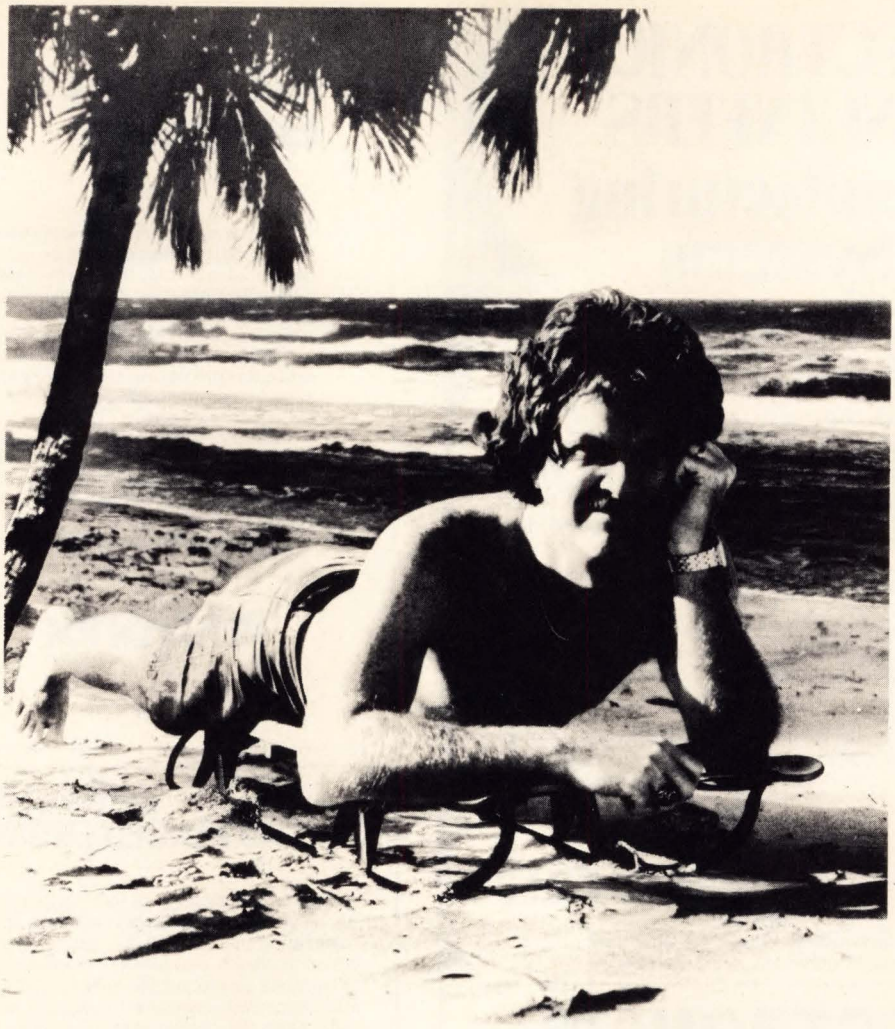

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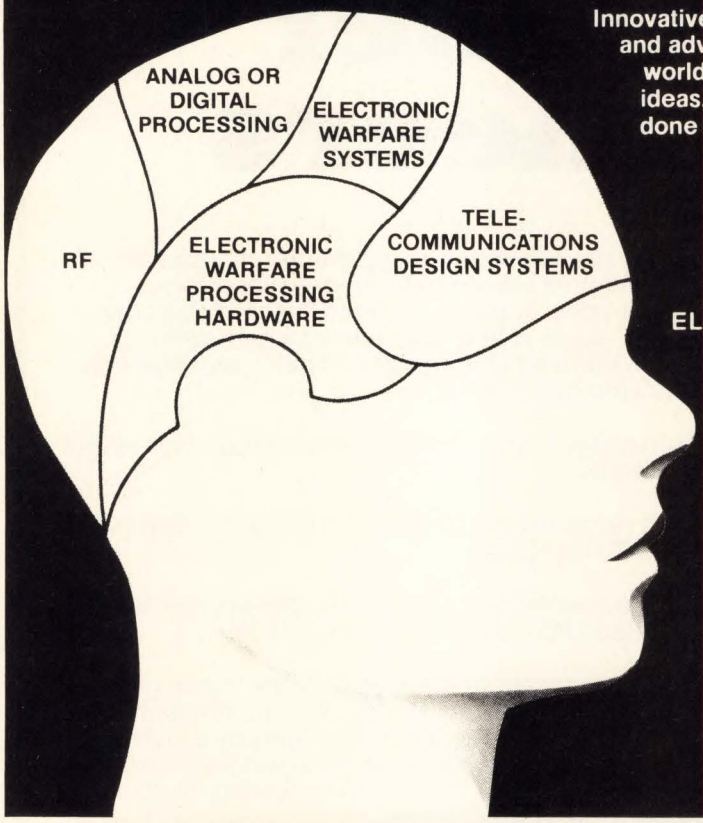

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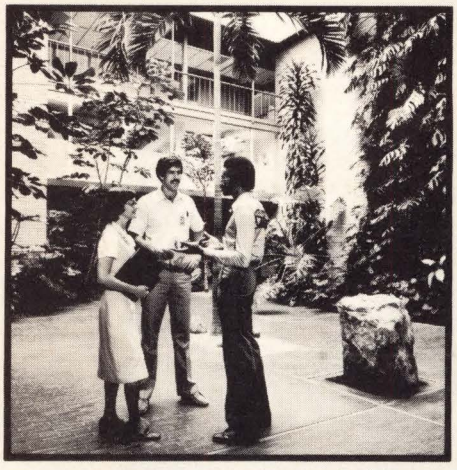

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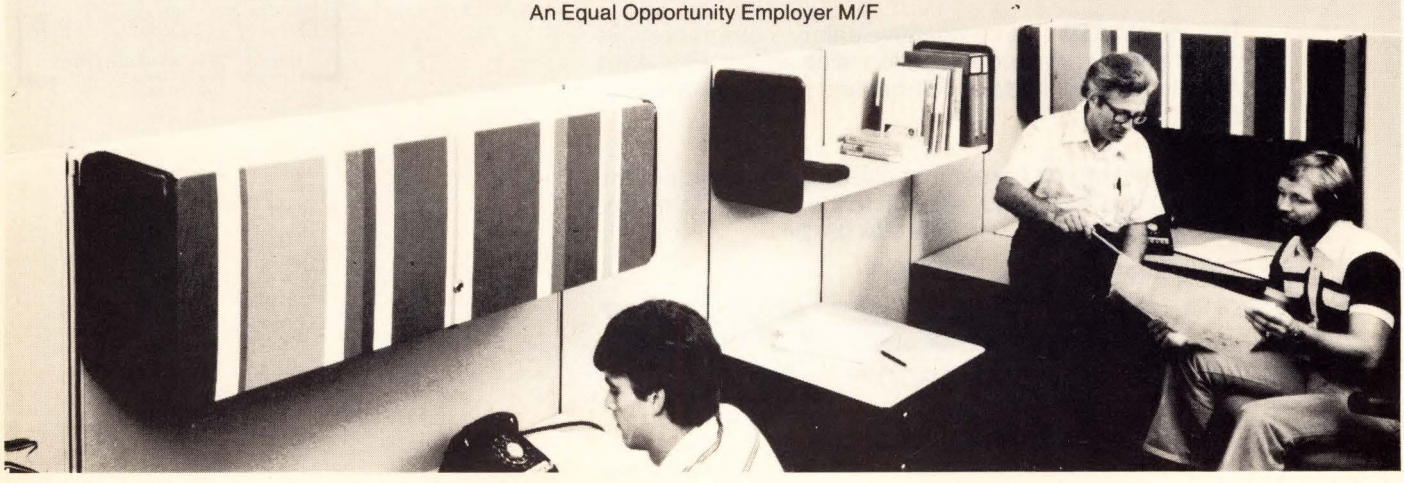

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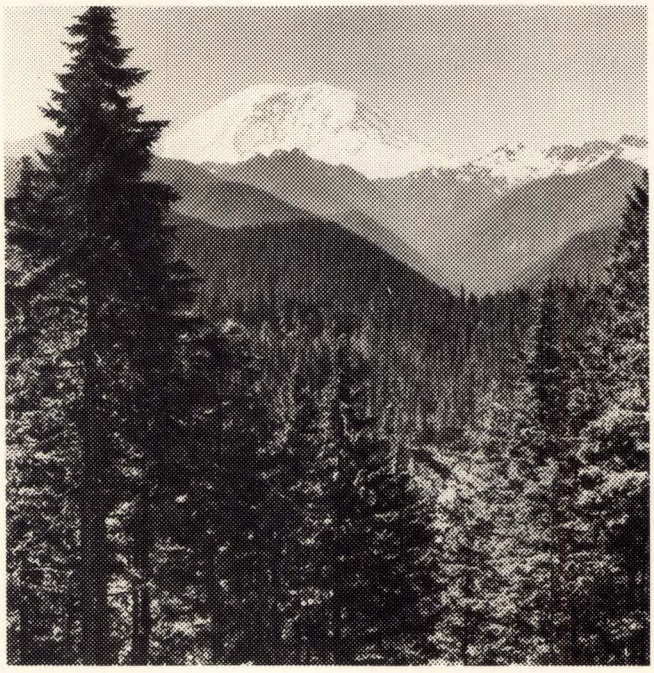

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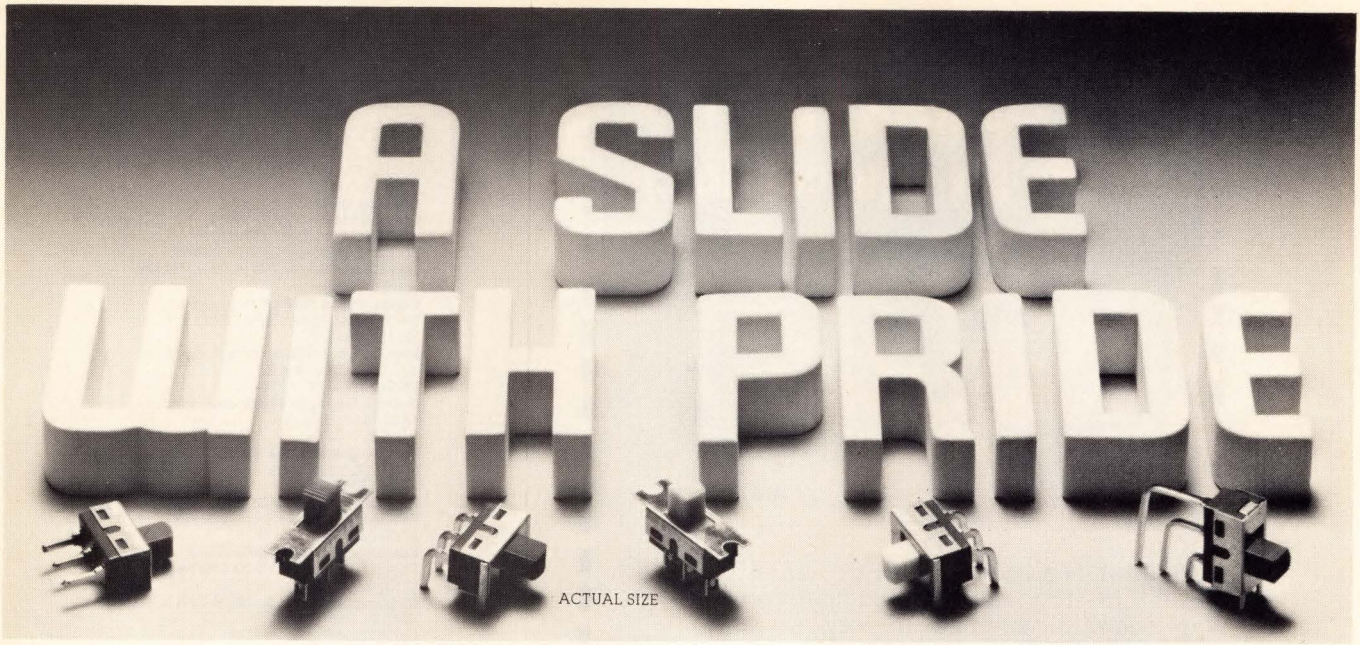

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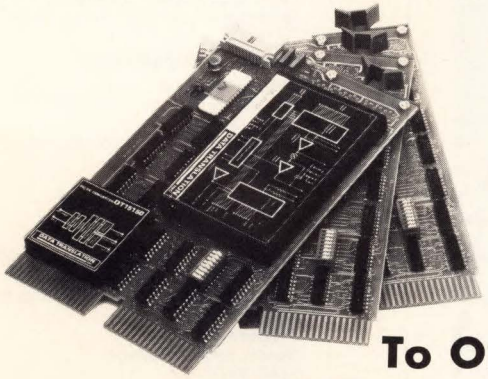

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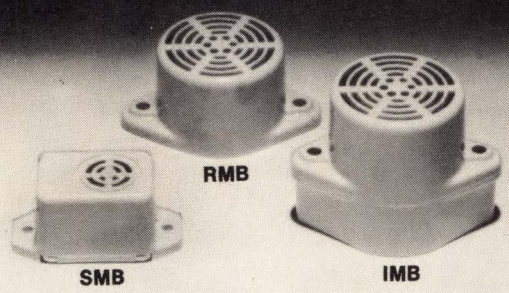

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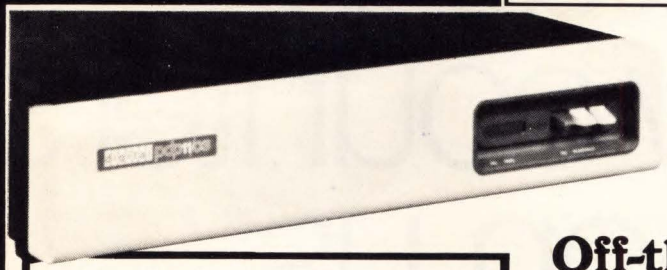

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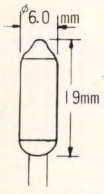

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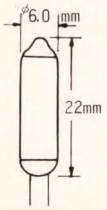

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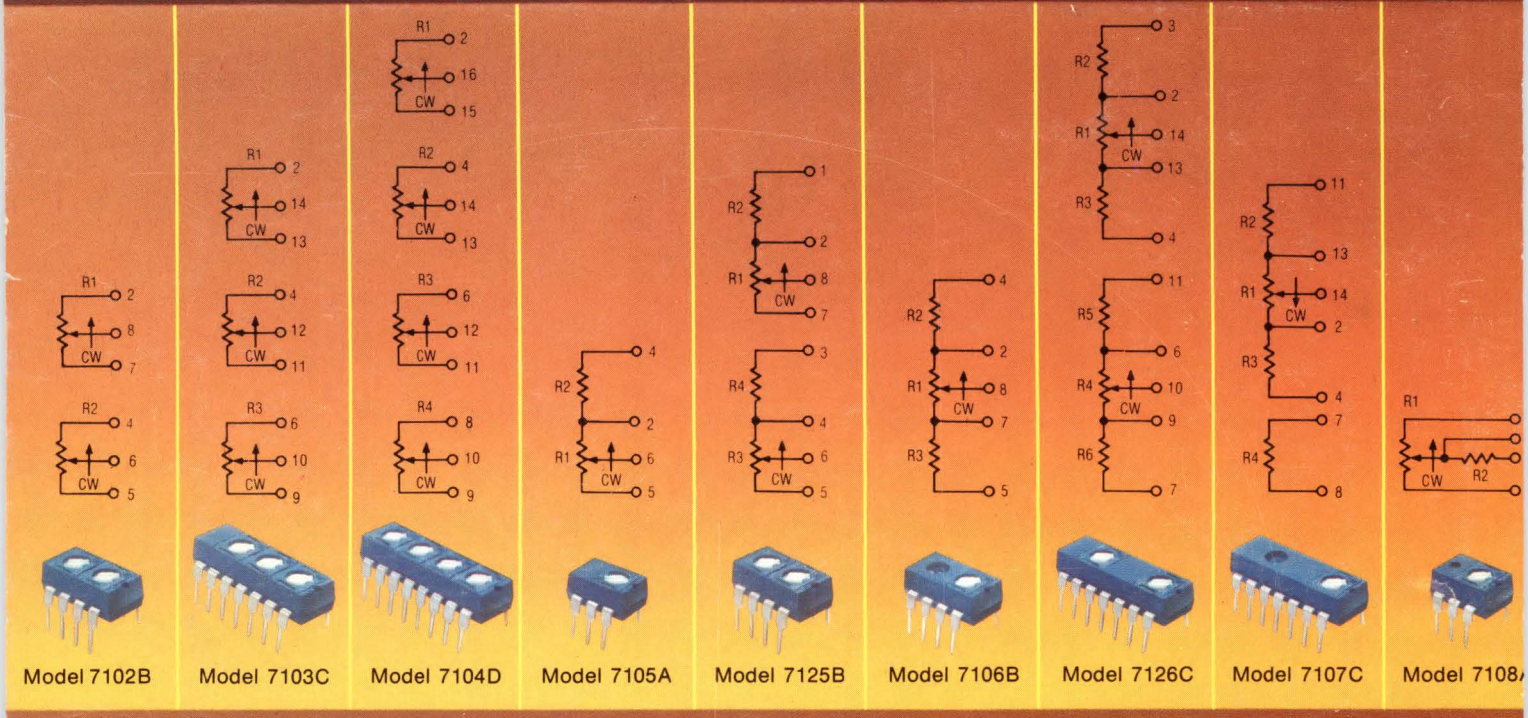

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